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The Foundry Trades' Equipment and Supplies Association

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Contents

	PAGE
Stainless Steel	355
Level Pegging	355
American Foundrymen Honoured	356
Marine Corrosion	356
Student's Corner	356
Cast-Iron Pipes	357
The Fracture of Pig-Iron	363
The Corrosion Research	364
Catalogue Received	364
Leaves from a Foundryman's Notebook, XI	365
Present-Day Position of Die Casting	365
Vitreous Enamelling Section—	
Acid-Proof Enamelling on Cast Iron	366
I.V.E.: Annual General Meeting in Birmingham	368
Enamel Mill-Room Practice	369
Refractories for Enamelling Muffle Furnaces	372
This Week's News in Brief	374
Trade Talk	374
Contracts Open	374
Personal	374
Forthcoming Events	374
Raw Material Markets	376

Stainless Steel

The development of stainless steel may be well described as a modern metallurgical miracle, and some sidelights not usually given in more formal Papers were thrown on the development of the material in a recent lecture in Sheffield by Dr. Hatfield. Starting with the metallurgical opinion current in 1914 that the production of a cheap practically incorrodible form of iron and steel was remote, reference was made to actual samples of a rustless steel tray and a rustless knife. The latter represented the original type of rustless steel, containing 13 per cent. of chromium, capable of being hardened and subsequently tempered. The former represented the later type of austenitic steel, containing both nickel and chromium, 18 per cent. of the latter and 8 per cent. of the former, soft and not capable of heat-treatment. In spite of the great increase in cost following on the use of the alloy additions, it is stated that the austenitic stainless steel is supplied to cutlery manufacturers to-day at a price very much lower than that paid for the old shear steel, a reduction brought about by research and investigation.

Taking the two steels as the older 13 per cent. chromium type and the newer austenitic type, of the total production of each, the aircraft industry takes 15 per cent. of the former and 4 per cent. of the latter, while engineering takes 58 per cent. and 31.5 per cent. respectively. Household and domestic ware absorb 21 per cent. and 10 per cent. respectively, but the consumption of the austenitic type is increased by architecture 6.5 per cent., and food industries 6.25 per cent.

An interesting fact emerges that all steels cannot be made rustless, because there is over 5 per cent. of iron in the earth's crust and less than 0.04 per cent. of chromium. The history of stainless steel is very illuminating. Chromium was discovered in 1797, and Faraday used it as an alloying element in steels in 1820, and in 1872 a patent was taken out for the addition of chromium. In 1892 Sir Robert Hadfield published experiments on the addition of chromium up to 16 per cent., but did his corrosion experiments in nitric acid, and Guillet, in 1904, omitted to recognise the corrosion-resisting properties. In 1911 Monnartz showed the improved corrosion resistance due to chromium, but industry ignored what seemed to be an academic discovery. In 1912 Mr. Harry Brearley noticed that a 13 per cent. chromium steel made for rifle barrels did not rust in the laboratory, and responded to different etching reagents according to the heat-treatment. From this to stainless cutlery was a short step, and the austenitic steel, with the nickel addition, followed, being worked out concurrently in this country and Germany.

Level Pegging

Having descended from their paradise, buyers are now regaining their sense of proportion; and realising that they cannot any longer browbeat the foundry salesman into quoting a lower price than that given by the last representative to call, they are apparently attempting to place their orders where they will be most appreciated. This at least is the impression gained by several representatives with whom we have recently made contact. They report that buyers are asking them to supply a complete description of their foundries, and actually they have sought our aid.

What, then, does a buyer need to know about each supplying foundry? We suggest that the information given should be along the following lines:—

(1) A list of the alloys currently handled with the weight-range attached to each type.

(2) A list of sizes of plates which can be used with the moulding machines installed, and the number of machines available; in this connection it may be desirable to indicate that certain machines are booked up for certain periods.

(3) The potential output per week, dissected if thought worth while, comprises further information useful to the buyer.

(4) Some indication should be given as to the facilities for patternmaking, fettling, and machining.

(5) If auxiliary departments exist for plating, tinning, galvanising or enamelling, these should be listed.

(6) Naturally, the buyer will want to know something about inspection and despatch facilities.

It might be thought that the detailing of such information would favour the larger foundries, but at the moment the speed of delivery for an odd casting or two is a strong recommendation for the placing of further business. Conditions are such that the quantity-production foundries no longer can go out of their way to oblige customers by doing one-off jobs, whilst the small jobbing foundries can fulfil their legitimate sphere in industry.

We are pleased to note this mental renaissance of the buyer, as it should do much towards the proper balancing of the industrial load. The astute buyer is obviously making an attempt to place his business, not necessarily in the cheapest market, but with foundries best equipped to supply the various sorts of castings he has to purchase. It seems desirable, therefore, for sales managers to encourage this new spirit, by preparing such schedules of plant capacity, and types and order of production for the use of their travellers.

American Foundrymen Honoured

DAVID McLAIN AND DR. H. RIES

The Board of Directors of the American Foundrymen's Association announces that acting on the recommendation of its Board of Awards, it is granting the Joseph S. Seaman Medal of the Association to Dr. Heinrich Ries in recognition of his outstanding services to the foundry industry and to the Association in the field of foundry sand research and control, and to Mr. David McLain it has awarded the J. H. Whiting Medal in recognition of his contributions to the foundry industry in stimulating better melting practices. The presentation of these medals will be made at the annual dinner of the Association held during the 1936 convention in Detroit this week.

Dr. Ries, professor of geology and head of the department at Cornell University, Ithaca, N.Y., was one of the first to direct scientific attention to foundry sand, having presented, before an A.F.A. meeting in 1905, a Paper on this subject, written as a result of his findings in making a geological survey of the sands of Wisconsin. When the Engineering Research

DR. H. RIES.

MR. DAVID MCLAIN.

Council, in 1920, organised the Joint Committee on Sand Research, he was called upon to aid in this co-operative work, and since that time has been a leader in this field, at the present time being Technical Director of the A.F.A. Committee on Foundry Sand Research.

Dr. Ries is a recognised international authority on economic geology, being the author of several outstanding books, including "Economic Geology," "Clay-Occurrence, Properties and Uses," and with T. L. Watson, "Engineering Geology." He is an honorary member and a past director of the A.F.A., a member of the American Institute of Mining and Metallurgical Engineers, Canadian Mining Institute, Ceramic Society of England, and a member and past president of the American Ceramic Society and of the Geologic Society of America.

Mr. David McLain, one of the most widely known men of the foundry industry, was born in Belfast, Ireland, November 11, 1863, and when five years old emigrated to the United States with his parents, who settled in Pittsburgh, Pa. When, less than ten years old and it became necessary to help support his family, he obtained his first foundry experience, twisting hay into ropes for core barrels. Continuing with the trade, Mr. McLain has led one of the most interesting careers in an industry which has produced many men of outstanding personalities and accomplishments. At fifteen years of age he was a moulder in the first successful steel foundry in America, and, after working in various steel foundries he became a foreman at 23 and had charge of the first Bessemer converter steel foundry in America. From 1897 to 1900 Mr. McLain operated a crucible steel foundry in Milwaukee, the city in which he has since made his home.

While superintendent of the steel, grey iron, and brass foundries for the Christensen Engineering Company of Milwaukee, now the National Brake & Electric Company, he completed his experiments on using large percentages of steel in cupola iron mixtures, pioneering in a field of melting practice, which was contrary to the tradition of that day, which was that steel was a harmful material to add to cast iron mixtures. While engaged in systematising foundries, from 1904 to 1908, Mr. McLain conceived the idea of incorporating his melting experience in text book form, and he initiated McLain's Systems, as a correspondence course in mixing irons and cupola practice, and in the production of what was known as semi-steel, the forerunner of modern high duty cast iron. Through his educational work Mr. McLain has been instrumental in creating improved melting practice, having had some 5,000 students using his instructions. Following the development of his course in iron foundry melting practice, he completed, in 1910, his system of steel foundry practice, giving advice on making steel castings by the electric, converter, and open hearth processes. Mr. McLain is well known in this country, and is an honorary member of the Institute of British Foundrymen.

Marine Corrosion

The Iron and Steel Institute has published Special Report No. 11 on "The Work of the Corrosion Committee," which has been prepared by DR. W. H. HATFIELD, F.R.S. (chairman of the Committee). We append the Committee's "practical conclusions" with regard to marine corrosion.

A. Field Tests.—**(1) The observations to date support the claim that there is some advantage in using copper steels, but the extent of this advantage cannot yet be accurately estimated.**

(2) Rolling procedure can influence the rate of descaling by weathering, and thereby affect the durability of paint applied to the weathered material. In particular, ingot iron and Scottish wrought iron held up before the last pass weathered very rapidly.

(3) Painting over partially-weathered scale is undesirable, since unrusted adherent scale gives better results. It is probable that pickled and sandblasted samples will give the best results if the material is to be painted, but this is not yet definite.

(4) It is desirable that an inhibitive paint* should be used for the initial painting of structural steelwork, and the most satisfactory paint of this type seems to be red lead.

B. Marine Work.—**(1) Most of the trouble with ships' hulls arises from the mechanical removal of paint.**

(2) For the best adherence of paint the surface should be thoroughly cleaned down and freed from loose material such as scale and rust before painting.

(3) There is definite evidence that pickling or sandblasting before the initial painting is advantageous.

C. Miscellaneous Examples of Corrosion.—**Segregation, it is believed, is liable to accelerate premature local corrosion, particularly under immersed conditions.**

* Paints such as red lead, which protect the metal against corrosion not only by excluding the corrosion agents but also by rendering the metal surfaces passive.

Students' Corner

SECOND SERIES

Cupola Practice—*(continued)*

Q. 8.—*After the cupola is fettled and the patching dried, how should one proceed with the charging?*

A.—In the case of a drop-bottom cupola, the tapping and slagging holes should receive attention and be made good before the hinged bottom doors are lifted and propped into position. The cupola bottom is then made good, by ramming with good floor sand mixed with a little new sand. This ramming must be done with care, for, if too hard, the metal, as it melts, will blow and scab, and, if too soft, the molten metal will eat into the sand and a run-out may eventually ensue from some of the hinge joints, or even the centre joint of the doors; this occurrence is by no means rare. The cupola bottom should be made in the same way as the bottom of a green-sand mould is made. With large cupolas the bottom can be completed from the inside, but with smaller ones this is partly done from the bottom, and usually finished through the cupola breast opening. With a solid bottomed cupola, of course, there is no attention given to the bottom so long as it is clean and sound, whilst the tapping and slagging holes are attended to through the breast opening.

In the case of small drop-bottom cupolas, and most of the solid bottom ones, the fire is kindled through the breast opening when this is built, or burnt through, as the case may be. Then the bed charge of coke is put on, and following this the first charge of metal. It is preferable that the pig-iron should be charged first, and the scrap after, especially if the scrap is small. In fact, small scrap is best avoided with the first charge, as it would probably result in hard iron in the first few small ladles tapped from the cupola. This would make castings of thin section brittle. However, it is not of much importance when a large ladle of iron is tapped first, or if there is a receiver attached to the cupola. Small thin scrap absorbs more sulphur and loses more silicon than does pig-iron or heavy scrap, and also becomes red hot some distance above the melting zone and is exposed to sulphur from the heavy bed-charge of coke. Heavy scrap or pig should retain their forms until the melting zone is reached, but small scrap trickles down saturated with sulphur, thus tending to give a hard, brittle and sometimes white iron.

After the scrap, is added the limestone, or fluorspar, and this completes the first charge. More coke, metal and flux forms the second charge, which is repeated until the cupola is full. Each charge should be evenly distributed over the area of the cupola—this does not receive the attention it deserves.

Q. 9.—*What is the function of fluxing material, and how much is required per ton of iron melted?*

A.—The fluxing material is either in the form of limestone or fluorspar, both of which are suitable for cupola melting. The function of the flux is to form a fusible slag with any foreign matter, silica, coke, ash, etc., and to some extent reduce the sulphur. The amount of fluxing material required per ton of iron varies according to the amount of sand and dirt adhering to the pig-iron and scrap, and also the ash content of the coke. With clean scrap, and if there is little sand adhering to the pig-iron and the coke ash content is within the analysis given, suitable limestone, under favourable conditions, may be as low as 28 lbs. per ton. Under adverse conditions, however, 60 to 100 lbs. may be required for fluxing.

(To be continued.)

Cast-Iron Pipes*

By W. WOODHOUSE, F.I.C.

Introduction

Cast-iron pipes are used chiefly for the conveyance of water, sewage and gas; they are also used for steam and other purposes. To-day they are an essential part of any civilised country.

Previous to the introduction of cast-iron pipes, pipes for the conveyance of water were made of clay, examples of which have been discovered at Nippur in Mesopotamia. Terracotta water and drain pipes have been found in the Palace of Minos at Cnossus. These date from about 2000 B.C., and examples are shown in Fig. 1. During the advanced civilisation attained by the Greeks in the centuries preceding the Christian era, an extensive use was made of clay pipes glazed inside and jointed with lead.

Metal pipes were first used by the Romans, who made water mains of sheet lead folded into tubular form and soldered at the edges, examples of which are shown in Fig. 2. These pipes were usually 10 ft. long and ranged from 5 in. (60 lbs. per length) to 100 in. (1,200 lbs. per length). During the occupation of this country by the Romans, both lead and wooden pipes were used. Examples of these have been found in the Roman cities of Caervent (Gloucestershire) and Uriconium (Shrewsbury). The use of wooden pipes (Fig. 3) made from bored tree trunks continued in England to the beginning of the 19th century. The timber used for the pipes was mostly elm and fir. Later on stone pipes (Fig. 4) were introduced. The Manchester Water Works Company used these in 1813. Owing to the porosity of the stone and consequent heavy water leakage, the use of this class of pipe was soon discontinued.

FIG. 1.—GREEK AND ROMAN POTTERY PIPES.

FIG. 2.—ROMAN LEAD PIPES.

Cast-Iron Pipes

Cast-iron pipes were first manufactured over 250 years ago. The earliest authentic record dates back to 1664-1668 when cast-iron mains were installed at Versailles to supply water to the celebrated Fountains in the Palace Gardens. Many of the original pipes are still in service and often cited to prove the "life" of cast iron. These pipes are 3 ft. 4 in. long and vary in diameter from 20 in. to 12¾ in., and from observation they were moulded and cast in a horizontal position.

Bank Pipe Foundry

About the middle of the 19th century the practice of horizontal casting was suspended by a system of oblique casting on inclined beds, called a "bank." Such a foundry is illustrated in Fig. 5. In this process the moulding boxes are divided into top and bottom halves. The moulds are placed at an angle of approximately 30 deg. Sand is bedded in the lower half of the mould and then sufficient sand is removed with a strickle, so that the pattern is at the correct depth when bedded in. The mould is prepared in green sand. The facing sand has the following composition:—Erith weak loam 33⅓, floor sand 33⅓, and pond duff, 33⅓ per cent. (Pond duff is coal from the bottom of settling ponds or tanks, and contains water 16-30, ash 18-36, vol. 15-22, and carbon 24-36.) Sand is now rammed down the side of the pattern and scraped off. Parting sand is sprinkled on the mould and the top half is put on and rammed. The top is lifted off and the pattern removed.

The core is "swept up" in loam and, when set in place in the mould, a chaplet is put in the top half to give the required thickness. The top half, provided with runner and risers, is then clamped in position and the metal poured into the upper end of the mould.

The metal requires to be hot and fluid, about 1,350 deg. C. The metal lifts the core to give correct thickness, but if it is "sluggish," the core does not lift, and thick and thin pipes are produced. Casting by this method, there is a tendency for blowholes in the pipes due to insufficient venting or damp moulds; there is also a liability to lack of concentricity in the pipes. Pipes from 2 in. to 6 in. dia. in 9-ft. lengths are made by this method.

Vertical Pit Casting

In 1846 Mr. D. Y. Stewart, of the Links Foundry, Montrose, obtained a patent for a method of producing vertically-cast iron pipes. According to a local legend, Mr. Stewart conceived his process while in church, the root idea being suggested by the vertical columns in front of him.

When vertical casting was first introduced, it was customary to form the socket at the upper end of the moulding box, but it was later discovered that by casting with the socket downwards, the metal became denser and stronger due to the head above it, thus strengthening the pipe in the most desirable place. This method also permits of casting a head on the spigot end of the pipe, into which sand, scum,

FIG. 3.—WOODEN PIPE UNEARTHED IN PICCADILLY.

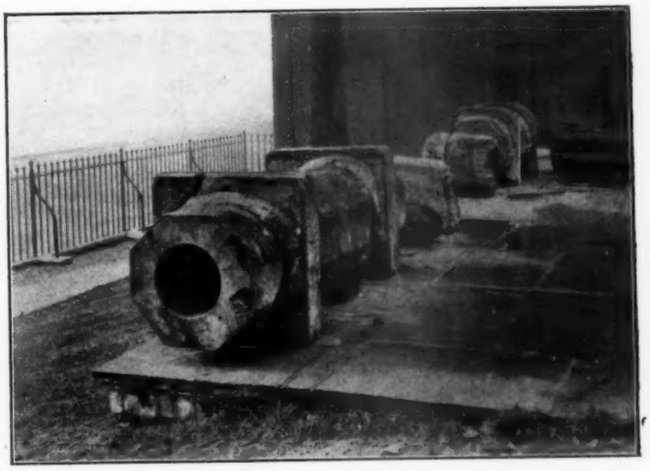


FIG. 4.—OLD STONE PIPES, BELIEVED TO HAVE BEEN USED BY THE OLD WEST MIDDLESEX & GRAND JUNCTION WATER COMPANY IN 1807.

* Lecture given to the Sheffield Branch of the Institute of British Foundrymen, Mr. A. Whiteley presiding.

etc., can rise. This head is afterwards cut off in a lathe.

In the manufacture of vertically sand-cast pipes it is usual to range the moulding boxes round the sides of circular, semi-circular or rectangular pipe pits. They are illustrated in Figs. 6 and 7. The moulding boxes are belled at the upper and lower ends and open on slides or hinges to enable the socket to be withdrawn. Sizes from 1½ to 2 in. to 75 in. diameter are cast in this class of pit. For sizes up to 27 in. the cores are made on perforated barrels. For the larger sizes to 75 in. dia. collapsible core-bars are used.

Fig. 5.—General View of a Bank Pipe Foundry.

The Ardelt Process

A more recent construction is to fix the moulding boxes to circular turntables such as is carried out in the Ardelt process. In the circular and rectangular pits the ramming is done by hand, but in the Ardelt process by mechanical means. The sequence of moulding is common to both types of shops, so that a description of the Ardelt process will answer for both processes.

Pipes produced by the method of vertical moulding are cast to dimensions within fine limits. Iron patterns, accurately machined and having a smooth finish, are used to form the outer part of the mould for the body and socket of the pipes, the bore of the pipe and socket being formed by cores. All tackle used for casting pipes in this way is machined to gauges so that the components of a mould are readily interchangeable.

Fig. 6.—Circular Vertical Pipe Pit.

The "Ardelt" pipe foundry belonging to the Stanton Ironworks Company, Limited, is one of the most up-to-date plants in this country for the production of vertically-cast iron pipes made in dried-sand moulds. The moulding boxes are fixed to circular turntables, so that the bottom of the boxes are a few feet above floor level. This necessitates a high building (60 ft. high) having two floors. On the ground floor all work in connection with the *sockets* is done. This consists of preparation of the sand, making and drying of the socket core. On the upper floor, the moulds are rammed, central cores prepared and the pipes are cast and stripped from the mould.

Moulding Plant

The building contains three cylindrical tables or drums 19 ft. in dia. by 7⅛ ft. deep, which are built up of steel sections encircled by steel plates. These are mounted on two cast-iron rings which carry the vertical moulding boxes. The tables, one of which is shown in Fig. 8, are supported on massive cast-iron bases and are revolved by electric motors operating through three sets of gearing. When the table is fully loaded the total weight is approximately 90 tons, but as this is carried on a ball bearing having 2½-in. steel balls, the 6-h.p. "series-wound" motor turns it without difficulty.

Tables 1 and 2 carry 36 boxes each, and each table has a 5-ton electric centre crane and is capable of turning out 144 4-in. pipes 12 ft. long per 10-hr. shift. Table No. 3 carries 28 boxes, has an 8-ton centre crane and can produce 98 pipes either 8, 9, 10 or 12 ft. per shift.

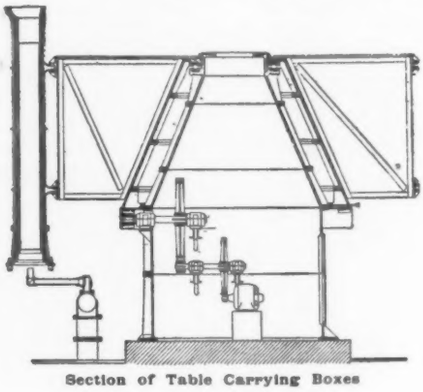
A ramming base to which the socket pattern is attached is fixed on the bottom of the mould and the lower end of the pattern drops into a tapered joint in the socket pattern (Fig. 9).

"*Bottom Sand.*"—A specially-milled sand, somewhat stronger than the floor sand, is supplied for ramming the mould to about a foot above the socket. This sand gives a higher mould strength at a point where the liquid metal exerts the greatest tangential force. The sand mixture used is best red moulding sand 45 per cent., black sand 50, and manure 5 per cent.

Fig. 7.—Rectangular Vertical Pipe Pit.

"*Floor Sand.*"—The remainder of the ramming is carried out with floor sand. No direct addition of new sand is made to this floor sand. The strength is maintained by the "bottom-sand" additions and clay water up to 5 per cent. After stripping the moulds, the sand is knocked out on to the floor and is fed into a vertical bucket elevator enclosed in a sheet-steel casing, which takes it up to the top floor, all the sand passing through a rotary sieve before being delivered into the storage hopper situated at the side of the ramming machine.

The ramming of the moulds is done by an electric ramming machine (Fig. 11), which is an important feature of the Ardelt plant. The four blades revolve, shown in Fig. 11, and the rammer is mounted on a table, which swivels over the mould. The table is revolved by a pinion drive engaged with a gear wheel running round the table. There are four blades, and rods pass through four guide holes in a square plate. The centre piece is worked up and down by a crank action. A split fibre brush in each guide hole is fitted with a spring, and the rammer rods are held in the brush when descending and slip



Section of Table Carrying Boxes

Fig. 8.

through when ascending. This machine is almost human in its imitation of hand ramming, except that it always strikes a uniform blow, thus ensuring a mould with a ramming density constant throughout, and from mould to mould. This constant ramming density gives a pipe of uniform section throughout. The time to ram a 4-in. mould is 2¼ min., whilst for a 12-in. mould it is 3¾ min.

corresponding to the pitch of the boxes. Fig. 12 shows the drying of the moulds with gas.

Thus, nine boxes are rammed, blacked and brought over the burners; these are then moved from the burners and are now ready for "coring," whilst a similar procedure is carried out with a further nine moulds. Whilst this ramming has been carried out, the striking of the main cores in special loam has been proceeding.

is adjusted by altering the loam thickness on the bar.

A necessary function of the core is that it should yield or give at the time of casting, under the pressure of the contracting pipe, so that the core-bar may be removed without difficulty. To attain this, the hot core-bar is splashed with a slurry composed chiefly of horse manure, well ground in the loam mill. This

FIG. 9.—PLACING THE SOCKET PATTERN IN POSITION.

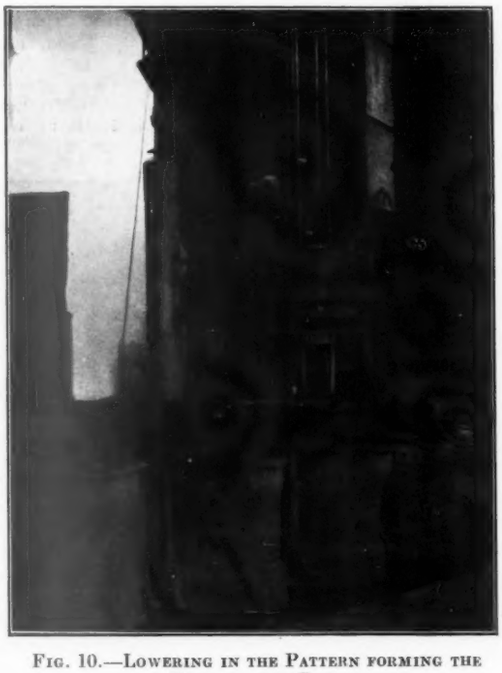


FIG. 10.—LOWERING IN THE PATTERN FORMING THE BODY OF THE PIPE.

FIG. 11.—VIEW OF RAMMING MACHINE.

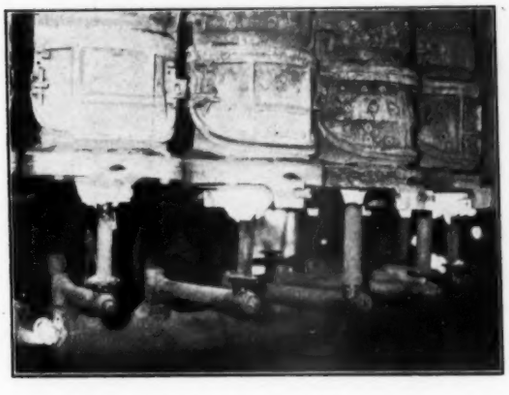


FIG. 12.—DRYING THE MOULDS WITH GAS.

When the ramming is completed, the pattern is withdrawn, and the table is moved round the pitch of one box. This mould (No. 1) is then blacked, while another mould (No. 2) is being rammed. When the table is moved again, No. 3 mould is rammed, No. 2 mould blacked and No. 1 mould is brought over No. 1 of a series of nine gas jets set at a distance round the table

"Body Cores"

The body core is "struck" on a perforated cast-iron bar, with special loam to give the correct dimension of the pipe. Different sets of core-bars are provided when making the various sizes of pipes, 4, 6, 8, 10 and 12 in., but for classes A, B, C and D, in which each size of pipe is made, the difference in metal thickness

"roughing" forms a spongy mass on drying, which later easily compresses under the contraction of the cooling pipe.

When this roughing is dry, the core is struck up with loam. The core-bar is placed in sockets at either end of the core table and the core is revolved by the wheel seen at the left-hand side of Fig. 13. In front of the bar is a long shelf

on which is the loam, and this is worked by hand on to the bar and strickled off to the correct diameter. The loam is prepared in a mill having a stationary pan, in which run a roller and a serrated chopping wheel.

The loam mixture consists usually of 60 per cent. spent core sand; 30 per cent. new red moulding sand, and 10 per cent. manure to which is added 24 per cent. of water. This mixture

FIG. 13.—STRIKING UP THE MAIN CORE. THE FINISHED CORES AT THE REAR ARE SEEN ENTERING THE DRYING STOVES.

varies somewhat according to the qualities of the new sand. These loams are tested every day for tensile and permeability. The tensile strength runs from 35 to 40 lbs. sq. in. and the permeability varies from 150 to 200 secs.

A loam of this character meets the heavy demands made upon it and is sufficiently permeable to allow of the ready escape of the gases. The cores when struck are passed into the drying stoves to dry preparatory to being placed in the mould. Each casting table is provided with two core making tables and two drying ovens. The core stoves are provided with recording thermographs for controlling the heat in the stove, which is round about 400 deg. Fah.

Socket Cores

These are prepared on the ground floor and are made with a sand having a high dried-bond strength. They are made from good red moulding sand, 66; clay, 20, and manure, 14 per cent. This is milled for 5 minutes in an edge runner type of mill and is delivered to the socket-core-makers' benches in hoppers running on light-gauge rails.

The body and socket cores are both blacked and dried previous to putting them into the mould. The number of core-bars necessary for ensuring a continuous cycle of operations is 72 for tables 1 and 2 and 56 for table 3. The number of "kellets" for the socket-cores is the same.

The system of working, length of time in drying, etc., of all work on the sockets is made to coincide exactly with that of the body cores, so that a set of each cores is ready at the same time. The mould now dried and ready, the socket core is raised into position by means of a hydraulic lift, situated in a position on the ground floor exactly corresponding with the position of the rammer on the upper floor. The body core is lowered into position, the tapered end fitting into the recess in the socket core. Casting cakes are placed in position at the top of the mould and casting is proceeded with. When the metal is set, the core-bars are loosened and removed, the moulds are opened and the pipes withdrawn.

The pipes run down an incline to the gantries on the ground level outside the moulding shop, where they are fettled. From here they pass on to the lathes where the casting head is cut off. They are then tested by hydraulic pressure to 100 per cent. over the working load and during this pressure-test they are hit by a 2-lb. hammer at various places along their length. This operation is shown in Fig. 14. This load varies with the diameter and class of pipe. After testing and inspection, the pipes are coated and are then ready for despatch.

The complete cycle of operations on the table are: ramming, blacking, drying, coring, casting, stripping, through which course the table makes one revolution. The methods in the other types of vertical casting are similar to those already mentioned, with the exception that the moulds do not rotate and that the ramming is not mechanical.

FIG. 14.—HYDRAULIC TESTING OF CAST-IRON PIPE.

Centrifugally-Spun Cast Pipes

The application of centrifugal force to the casting of metal is the subject of patents dating back as far as 1809. The first inventor, however, to develop a system of centrifugal casting with commercial possibilities was Mr. Seusaud de Lavaud, a French engineer, who began his investigations in Brazil in the year 1914. The Stanton Ironworks Company, Limited, developed the De Lavaud system of centrifugal pipe casting from the experimental stage and began producing pipes by this process in a small plant in 1922. A large plant was put into operation in 1924 and has been considerably extended since that time and is still increasing.

Considerably over 16,000 miles of De Lavaud centrifugally-spun pipes have been supplied by the Stanton Company up to the present time. These pipes are produced in sizes from 3 in. to 21 in. diameter up to 18 ft. in length, and are also made in metric sizes for export. Since the establishment of the spun plant at Stanton, the De Lavaud system has also been

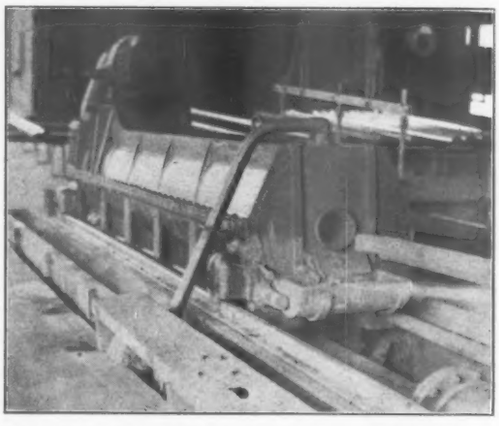


FIG. 15.—WATER-BOX CONTAINING THE MOULD.

adopted by important firms in the United States of America, Germany, France, Belgium, Canada, Australia and Japan.

The plant is designed on the straight-flow principle. All raw materials enter the works at a high level at one end and the finished pipes, gravitating through stages, leave at the other end. At this plant there are eight cupolas, each having a continuous melting capacity of 10 to 15 tons per hour, and each cupola on blow runs continuously for 20 hours. There are four cupolas blowing each day. These cupolas are mechanically charged.

The pig-iron and scrap charge is apportioned on analysis to give the requisite silicon content in the molten metal, whilst all charges of iron, coke and limestone are weighed. For further control samples of the molten metal are taken every 1½ hrs. and analysed for silicon and sulphur, and the phosphorus, manganese and carbon contents are ascertained every 6 hrs.

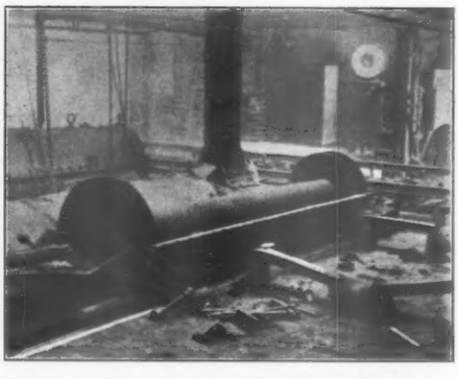


FIG. 16.—MACHINE WITH TOP HALF OF WATER-BOX REMOVED.

The blast volume and pressure are controlled with a Wilson blast recorder. This analytical control of cupola supplies and resultant metal applies to all the cupolas at the various foundries belonging to the Stanton Company.

The molten metal at a temperature of 1,400 deg. C. is run into 50-cwt. casting ladles which are conveyed into the casting shops by overhead

electric telpher cranes. The plant consists of two units, one for the manufacture of pipes up to 4 metres long the other for pipes up to 18 ft. in length, each unit being capable of working independently of the other. With the exception of a short socket core no sand or loam moulds or cores are used. This automatically obviates the risk of certain defects, which cannot always be avoided in sand casting, such as sand holes, blowholes, cold shot, etc.

Briefly, the molten metal is introduced into a revolving water-cooled steel mould and the mould at the socket end. When the socket portion is full, the water box travels in a downward direction.

Due to the combination of the axial and circumferential movements, a continuous spiral of molten metal is deposited on the inside of the mould, and knits together, thus forming the pipe. The finish of the casting process is shown in Fig. 18.

It will be realised that a true pipe can be formed to any required thickness by the adjustment of those three movements. For instance, then gradually cool to a temperature of 315 deg. C. at the exit of the furnace.

The transit of the pipes through the normalising furnace is controlled by a conveyor which also keeps the pipes revolving. The furnace is heated with producer gas and the temperature is controlled by means of thermocouples and radiation pyrometers coupled to recording instruments. After leaving the furnace the inside of the pipe is scrubbed by a pipe scouring machine, after which it is inspected and passed to the dipping tanks where it is coated. It is then hydraulically tested, after which it is ready for despatch.

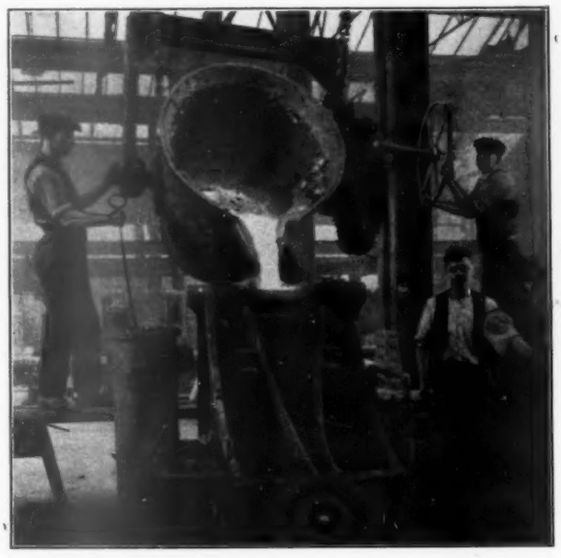


Fig. 17.—Fall Spout, and Filling of Tilting Hopper.

Fig. 18.—Finish of Casting.

centrifugal force holds the metal against the sides of the mould. As the mould requires no preparation, casting is practically continuous, enabling output to be increased in comparison with the sand-cast method by eight times per head of labour employed.

In the casting shop batteries of machines are situated on either side of a central platform. The overhead telpher track for carrying the ladles of molten metal is located in such a position that the ladle is in alignment with the head of each machine.

The casting machine, shown in Fig. 15, consists of a water box containing a steel mould rotating on friction rollers and driven by an electric motor. This mould is accurately machined, the inside diameter conforming to the outer profile of the pipe. These moulds are manufactured of special steel. Fig. 16 shows the mould in the bottom half of the water box. This water box containing the mould is mounted on rollers and is traversed along a steel track on the machine bed, which is slightly inclined.

This movement is actuated by means of a hydraulic cylinder and ram, the latter being attached to the underside of the water box. The speed is controlled within very narrow limits by means of a fine adjustment valve. At the upper end of the inclined bed is a frame to which is attached at the back a tilting hopper, which has a metal carrying capacity just sufficient to cast one pipe. On the other side of this frame is a fall spout (Fig. 17) leading to a long cantilever pouring trough. The tilting hopper, which is hydraulically operated, is shaped so that during casting the molten metal is discharged to the mould at a uniform rate.

The procedure for casting a pipe is as follows: A sand core, to form the inside of the socket, is inserted in a taper seat at the socket end of the mould, and the water box is then moved up to the top of its track. The mould is revolved and the hopper, which has been previously filled with molten metal, commences to tilt. A uniform stream of iron flows down the fall spout and trough, and is projected into the having determined the correct peripheral speed of the mould, *i.e.*, that which exercises sufficient centrifugal force to hold the metal against the wall of the mould, and knowing the rate of discharge of the tilting hopper, the speed of traverse is adjusted to suit the thickness of the pipe. This speed of traverse varies with the size of pipe.

After removing the socket "kellet," the pipe is discharged from the mould by inserting internal grip tongues into the socket end of the pipe and moving the machine once again to the upper part of the track. This is shown in Fig. 19.

During this operation arms automatically function, temporarily supporting the pipe until it is picked up by a transfer mechanism and deposited on to an adjacent gantry, and this operation is shown in Fig. 20. The pipes roll along this gantry over a weighing machine to a normalising furnace.

As the pipes are cast in metal moulds a slight chill is formed in the outer skin. This chill is minimised to a large extent by sprinkling the inside of the steel mould with a predetermined amount of powdered ferro-silicon. The object of this normalising is two-fold, to remove the last traces of chill and to eliminate any casting strains. The pipes are kept at a temperature of 955 deg. C. for 15 min. in the hot zone and

The time for casting a spun pipe, of course, varies with the size. From putting the socket in place to removing the pipe to the gantry a 4-in. dia. pipe takes 2½ min., whilst a 15-in. dia. pipe takes 8 min. The sockets are struck up with a special mixture of sands, clay and a cereal binder to give a good strong socket.

The centrifugally-spun process subjects the metal to the influence of two important factors:—(1) Centrifugal force, and (2) rapid rate of solidification. Both of these enhance the structure and strength of the metal. Metal when cast in sand giving a tensile of 10 tons per sq. in. has a tensile strength of 15 to 20 tons per sq. in. when spun in a water-cooled metal mould—depending on the thickness of the pipe. This improved strength is primarily due to the effect

Fig. 19.—Withdrawing Pipe from Mould.

of rapid cooling, the centrifugal force contributing about 25 per cent. to the total improvement.

The rapid solidification of the metal causes the formation of a fine crystalline structure in which the graphite is evenly distributed in a very fine form. Centrifugal action prevents the formation of blowholes or other cavities in the section of the casting, any gases formed being expelled by this action. Owing to the improvement in the mechanical properties of the spun metal, it is possible to manufacture the spun pipe some 25 per cent. thinner in section than the corresponding sand-cast pipe and at the same time to produce a higher factor of safety.

Apart from the increased tensile strength of the spun pipe, tests representing various stresses, such as shock, external loads along the pipe, external loads transverse to the pipe—prove that the spun pipe is in all instances equal or superior, despite its reduced thickness, to sand-cast pipes. The normal tests specified for testing of the metal used in sand-cast pipes are transverse and tensile. As similar bars would not represent the metal in a spun pipe, a ring test has been devised and adopted for the determination of the tensile strength. Rings 1 in. wide are cut from the spigot end of the pipe and pulled in a testing machine in a similar way to testing the link of a chain. From a formula which has been evolved from many tests, the tensile strength of the metal can be calculated.

Fig. 21 shows the comparative deflections on sand-cast and spun pipes of 3-in. dia.

Comparative bending tests on 3 in. spun and sand-cast pipes show that, in the case of the spun pipe, the breaking load is greater by 71 per cent.; limit of elasticity is greater by 51 per cent.; elastic deformation is greater by 30 per cent.; total deflection is greater by 60 per cent.

Impact Testing Machine

The impact test gives a good indication of the resistance of cast-iron pipes to shocks received in transportation and in actual service. The pipe is held firmly in the machine, shown in Fig. 22, in 24-in. supports. A hammer weighing 50 lbs. is dropped on to the pipe, which is under an internal hydrostatic pressure of 65 lbs. per sq. in. The initial height of the hammer is 6 in., and succeeding blows are from heights increased by 2 in. The blows are all struck at the same point. The number and height of the blows are increased until the pipe fails. The height at which the first crack and first leak occur is noted. From an empirical calculation the impact is found in foot-pounds.

Coating

All pipes, bends and specials are coated before leaving the works. The pipes are heated either in a hot-water tank or oven before going into the dipping tank. In the case of spun pipes (Fig. 23), the residual heat in the pipes coming from the normalising furnace is sufficient without any further treatment.

The coating mixture consists of special refined tar containing 10 per cent. bitumen to which is added at times strained anthracene oil to control the consistency. The tar acids are kept as low as possible in this mixture, about 3 per cent. The mixture is kept at 150 deg. C. in the dipping tanks which are all controlled with recording thermographs. The pipes are kept in the dipping tank from 5 to 15 minutes according to size, when they are withdrawn and allowed to drain.

When extreme adverse conditions are expected, such as aggressive soils containing magnesium sulphate, calcium sulphate and other salts a special thick coating is put on the pipes. This consists of bitumen to which is added an inert filler and asbestos fibre to give additional strength. This coating is from $\frac{1}{16}$ to $\frac{1}{8}$ in. thick and is put on in a special machine.

When tubercule incrustation is encountered, the iron pipes are lined with centrifugally-spun concrete.

The Paper has now traced the various methods of making cast-iron pipes and arrived at the stage where they are ready for transit to be despatched to their various destinations all over the world.

In conclusion it seems desirable to quote the words of Mr. Henry S. Stilgoe, M.Inst.C.E., late Chief Engineer to the Metropolitan Water Board.

"I can always say of the cast-iron water-main that it is a well-tried, faithful and honest servant of the water engineer." This quotation is taken from an interesting book "Cast-Iron Pipe. Its Life and Service," published by the Stanton Ironworks Company, Limited.

The author wishes to thank the directors of the Stanton Ironworks Company and Mr. P. H. Wilson, foundry general manager, for permission to give the Paper.

Fig. 20.—General View of Casting Shop.

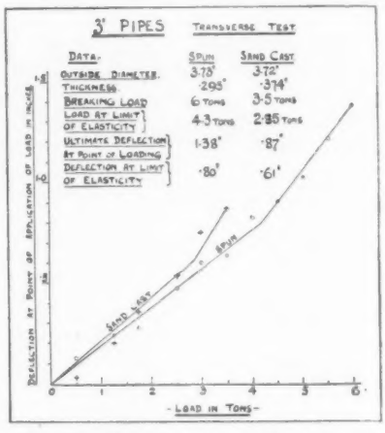


Fig. 21.—Curves showing Deflection obtainable on Sand-cast and Spun Pipes.

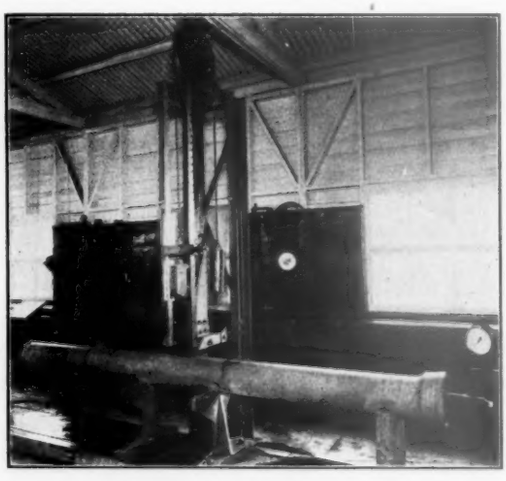


Fig. 22.—Impact Testing Machine.

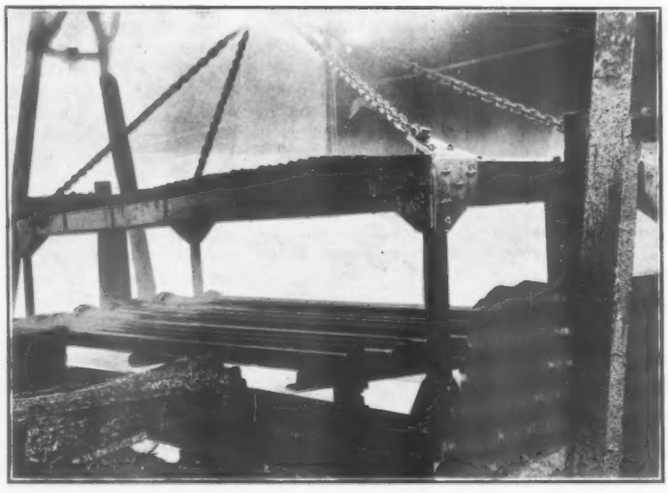


Fig. 23.—Cooling Spun Iron Pipes.

The Fracture of Pig-Iron

At a meeting of the Sheffield Branch of the Institute of British Foundrymen, DR. A. L. NORBURY, senior metallurgist to the British Cast Iron Research Association, gave a lecture upon "The Fracture of Pig-iron," but as this has been expanded in a Paper for the Annual Congress, we give a summary of the lecturer's remarks and the discussion which followed.

Synopsis

The effects of carbon and silicon on the fracture of pig-iron were indicated, and reasons why it is possible to get the same sort of No. 1 fracture in hematites containing 4 per cent. carbon with 2 per cent. silicon and 2 per cent. carbon with 10 per cent. silicon were discussed. The effect of blast-furnace operation on the analysis of the pig-iron produced was then indicated. Then differences in the fracture of pig-iron and cast iron arising from causes not revealed by the general chemical analysis were discussed, with special reference to the effect of the presence of small amounts of titanium slag inclusions. The effects of other factors, such as rate of cooling, carbon segregation and flotation, were finally referred to.

Hot and Cold Blast Pig-Irons

MR. J. ROXBURGH remarked that Dr. Norbury had given them a great deal to think about by his interesting lecture. He quite agreed with Dr. Norbury that analysis was not everything. The way that he looked upon cast iron for certain castings which he was called upon to make was, that having considered the service which a casting had to perform, he decided that it should possess a certain structure. With that in mind, the analysis was then taken as a guide to obtain that definite structure required. Then, too, the choice of materials, as Dr. Norbury had shown, was highly important. Probably Dr. Norbury would agree that the irons that were produced in the blast furnaces to-day under hot blast conditions were definitely inferior to what one obtained in years gone by. There was one interesting point in regard to blast furnace pig-iron upon which he would like some information. Dr. Norbury did not mention the fact that in some cases to-day those pigs were cast into pig casting machines, and he wondered whether the pig-iron cast into a chilled mould was superior in any way to that cast into a sand mould, and if the structure was improved by casting in a chilled mould and whether that structure was retained on subsequent re-melting.

In regard to the total carbon content taken into consideration with the silicon content, he was particularly interested in the hematite pig-iron which Dr. Norbury had shown. He had instanced hematite containing 4.2 per cent. total carbon, and silicon about 2.5 per cent., with a low phosphorus—0.03 per cent. When dealing with those very rich irons, ingot mould makers very often encountered a great deal of trouble due to the kish in the irons. It seemed to him that with hyper-eutectic irons with a very high total carbon the trouble was more or less inevitable. He wondered if Dr. Norbury would give them his views regarding the kish that one met with in that type of hematite? Dr. Norbury had shown them a slide giving particulars of two typical No. 4 fracture irons. In one case the No. 4 iron contained 4 per cent. total carbon and 1.5 per cent. silicon. In the other case the average composition was 3.5 total carbon and 2 per cent. silicon. His (Mr. Roxburgh's) contention was that with irons varying in total carbon such as those two, if the combined carbon obtained was the same, then, of course, with a higher total carbon, one would obtain a higher percentage of graphite distributed throughout the iron, and in that way a variation in fracture resulted.

Dr. Norbury had mentioned super-cooled cast iron. They were aware that this was something which perhaps was not new, but it was definitely something in which cast iron research workers were interested. He wondered if the manufacture of such an iron showing that sooty fracture was a commercial proposition, for instance, in the foundry. If they added titanium and bubbled carbon dioxide through the iron, could the iron be used for casting some particular job?

Speaking of the inverse chill which one sometimes found in a fracture, Mr. Roxburgh suggested to Dr. Norbury that probably the formation of a white centre or a close centre might be due to the outside of the particular fracture or section being cooled unduly, thus preventing any expansion when the graphitisation occurred, and so this action was prevented. He felt very much indebted to Dr. Norbury for his interesting lecture.

High Total Carbon Pig-Irons

DR. NORBURY said he thought it was generally agreed that the hot-blast furnaces of to-day produced higher carbon irons that were not as strong as the lower carbon irons that used to be produced in the old slower driven furnaces. The question as to whether pigs cast in chills were superior to those made in sand was an interesting one. Of course there was no sand on them for one thing. That in itself made a difference. He did not know what difference it made to the structure of the castings produced, but one effect could be that less fluxing material would be required and less slag produced on remelting.

He regarded analysis as the main thing of course, but there was also the question of non-metallic inclusions to be taken into consideration as governing the fracture of the castings produced. He did not think that the fine structure of a pig-iron cast in a chilled mould was reproduced on re-melting, but that it reverted to the normal fracture. One thing, however, that he always thought about chilled cast pigs was that the graphite was much finer and should dissolve more rapidly on remelting. One could imagine a very coarse iron, on the other hand, going down the cupola and as it melted some of the kish floated up out of the iron; this would result in the carbon being lower. The reason for the difference between the two No. 4 irons mentioned by Mr. Roxburgh was probably due to the difference in the graphite content. For the same fracture and same analysis apart from carbon there was more graphite in one iron than the other.

As to whether the production of the super-cooled graphite was a commercial proposition, Dr. Norbury said one could produce it under certain melting conditions but not yet under all melting conditions with sufficient certainty. Under most melting conditions slag inclusions got into the metal and upset the other inclusions. They were trying to find out where the other slag inclusions came from and how to keep them out. What Mr. Roxburgh had said about the expansion of the graphite was quite correct.

Gas Content of Pig-Iron

MR. T. R. WALKER said that his firm used a very large quantity of pig-iron at their works, but not for making iron castings, so that they did not look at pig-iron in quite the same light as most foundrymen. In steel making it was a fact that if they used pig-irons having the same apparent chemical composition in different casts, they did not always obtain steel with precisely the same properties. That was one reason why the best steelmakers used a mixture of different pig-irons to obtain a uniform product, such a product being much preferable to one which was variable.

It seemed to him as though the steel retained some memory of the pig-iron from which it was manufactured. He wondered if Dr. Norbury could tell them whether, in his opinion, this had anything to do with the gas content of the pig-irons since the irons certainly varied in the amount of gas they contained, according to their method of manufacture. In this connection, it was a fact that to-day some manufacturers of alloys purposely added gas, for example, nitrogen during the manufacture of the alloys. In America a considerable amount of ferro-chrome was being used, containing an appreciable amount of nitrogen which gave a very fine structure and could be used for making, say, stainless steel which retained the fine structure. He wondered if Dr. Norbury had considered the effect of nitrogen in modifying any of the micro-structures he had shown on the screen.

Titanium in Pig-Iron

He was also interested in what Dr. Norbury had said about titanium. Dr. Norbury had mentioned the presence of titanium in the form of titanium dioxide. Most steel contained titanium in small quantities, but whilst it did occur as titanium dioxide it was also found in micro-sections in the form of titanium nitride and titanium carbo-nitride.

With reference to what Mr. Roxburgh had said about the manufacture of ingot moulds from hematite irons, the firm with which he (Mr. Walker) was associated was one of those which formerly asked for ingot moulds containing low sulphur and phosphorus contents. The idea of this had been to enable the scrap moulds to be used in the charge for making acid open-hearth steel, but owing to the fact that they very rarely obtained moulds which complied with this specification, their present practice was to melt the moulds in basic furnaces, and to demand a long life for the moulds in preference to a low sulphur and phosphorus content.

DR. NORBURY said that the suggestion that something in the pig-iron affected the properties of the steel made, and that more uniform steel was made when a mixture of pig-iron was used, was very interesting. He wondered if Mr. Walker had any information about the effect on the steel of using a pig with a high titanium content.

Smelting Titanium Pig-Iron

MR. WALKER said that the pig-irons used by his firm did not contain much titanium. They consisted of hematite English pigs and Swedish pigs. They did not use Norwegian pig-iron. English and Swedish pig-irons both contained a little titanium, but the Norwegian contained a great deal more. They had used titanium as a deoxidiser for steel, in the form of alloy additions, but their objection to its use was that it caused non-metallic inclusions which were very detrimental for some applications of the steel. He would like to ask Dr. Norbury what he thought was the present attitude of pig-iron manufacturers towards ores containing a good deal of titanium, because attempts had been made to use them at intervals in the last fifty years, since they occurred in very large quantities and could be obtained very cheaply. Many plants had been started for this purpose in this country, but he believed that they had all closed down owing to the technical difficulties in the reduction of iron-titanium ores; year after year, however, new processes for reducing such ores were brought out.

DR. NORBURY said he understood that titanium ores were more difficult to handle in the blast furnace as they did not slag so nicely. He did not think that was the main reason they were not much used in this country, but they certainly altered the fracture of the pig-iron. If the fine fractured titanium-containing pig-iron was used for the right purposes in the foundry it would be good, but it was also not good for certain purposes.

MR. WALKER: We look upon it simply from a steelmaking point of view.

DR. NORBURY: It is a very interesting point if it is the non-metallic inclusions in the pig-iron that affect the steel.

Wanted—A Standard

Mr. F. Whitehouse said he would like to know what standard they could use for judging pig-iron. In the old days it was easy to judge by fracture. Then they turned over, so to speak, became scientific, and judged from the chemical composition. Now the scientists seemed to be a bit sorry for themselves and had decided that even the scientific way of looking at it, so far as chemical composition was concerned, was not good enough, and they were going back to the previous method of studying the fracture. Then, to make confusion worse, they were now told that the fracture itself was largely bound up with non-metallic inclusions. He thought that in the long run a foundryman like himself hardly knew what results to rely upon. It would be agreed that what foundrymen were concerned with, was as to which specification they should adopt when buying pig-iron. He gathered that the question of fracture had a great deal to do with the ores from which the pig-iron was made. He suggested that it had largely depended on the manner in which the pigs were made on the sand bed, and with the running of the blast furnace. He would like Dr. Norbury's opinion as to which was the more important. He was rather surprised to hear Dr. Norbury say that the coke charge had so largely affected the carbon content, because he had an idea that with a less coke ratio they still could produce a higher carbon pig-iron, and working from the same theory he had always believed that cold-blast iron demanded a higher ratio of coke, and he could not reconcile the two points of view. To-day they were driving faster and were using higher blast temperatures, and yet they could get very high carbons in common pig-iron.

Analysis Normally Adequate

Dr. Norbury said that if the air going into the blast furnace was not heated more coke had to be used. In ordinary modern furnaces if they wanted a more open fracture he understood that they put in more coke.

Mr. Whitehouse said that he thought that the open fracture was brought about by silicon or sulphur.

Dr. Norbury said that with regard to the best specification he thought it was only in certain cases that the properties which were not revealed by chemical analysis affected the castings. He did not think that in the general grey iron foundry they affected the castings to any considerable extent, although it might eventually be possible to make them have a greater effect by melting the irons under modified conditions. On the other hand, in some types of castings something that was not revealed by chemical analysis did definitely have a commercial effect. For example, with regard to malleable iron he thought it was fairly well established that when certain pigs had been used in the charge they had reduced the quality of the malleable iron resulting. This was something that had not been revealed by chemical analysis. There had been a very interesting discussion on this subject in the American Foundrymen's Association recently. They had a round table discussion on the quality of pig-iron, and discussed variations in cast iron and pig-iron that were not revealed by chemical analysis and the causes of these variations. However, he thought it was only in special cases where these things which were not revealed by chemical analysis had much effect. At the present time it appeared that the best thing was to find a pig-iron that suited a particular purpose and to stick to it.

Mr. Whitehouse remarked, "so we are more or less back to where we used to be when we worked by rule of thumb," and said he agreed that to-day one could buy two pig-irons of roughly the same chemical analysis and yet not get the same physical properties.

Dr. Norbury said that it might be found that the differences were due to some particular ore in the furnace, and when this was known they could control the furnace charge to give the sort of iron that was the best for a particular purpose.

A Modern Quandary

Mr. Winterton remarked that the old foundryman who used the fracture test of pig-iron as a method of estimating what sort of iron to use to get a certain result usually succeeded. Nowadays he looked at a set of figures which indicated he would get a certain result, and again he was generally successful. After the lecturer's statement that it was possible to get a No. 4 fracture from a No. 1 iron and *vice-versa*, in fact to get almost any kind of fracture from any analysis of iron, he was more than ever convinced that good foundrymen were born and not made.

Dr. Norbury said that he had attempted in his Paper to illustrate what could happen under certain conditions. Probably in most cases the differences did not arise in the castings produced to any considerable extent, but, on the other hand, in certain cases such differences definitely did affect them. The more they could understand and control such variations the better their products would be.

Mr. Roxburgh observed that if one wanted a close grained casting one would not think of using an open pig-iron to start with. That was fundamental. On the other hand, if they wanted, say, a pressure casting, they had to use close materials to commence with, such as good quality cylinder iron and scrap with a definite analysis. On the other hand they could get the same analysis by using hematite which had a very open structure, and adding some other material. The former would be pressure tight and the latter would not.

Where Fracture Wins

Mr. Walker said that there was no doubt that in some cases fracture afforded a much more delicate means of examination than the ordinary chemical analysis. For example, if they had a piece of steel which had been slightly burnt it could be picked out immediately by fracture, whereas in the chemical laboratory they would have to spend a long time before finding out anything wrong with the steel.

"Meat" and "Poison"

Mr. V. E. Upton pointed out that in some of the slides shown by Dr. Norbury it was indicated that as the silicon was increased the total carbon receded. He was interested in Dr. Norbury's remarks about drilling the pigs for samples and would like to know if Dr. Norbury had found any great variation in the total carbon and silicon, as some time ago they conducted a special research in drilling pigs from various angles for samples and the results were consistent so far as sulphur and phosphorus were concerned.

He was also interested in the question of pig-iron casts in chills instead of cast in sand. On a recent occasion they had sent to one firm over 1,000 tons of sand-cast and a similar quantity of chill cast. Both of them had the same analysis and finally, the preference was given to chill cast. Strangely enough another firm making exactly the same product had difficulty and there the chemist decided that the trouble was due to chill cast pigs and asked for sand cast pigs in future.

Dr. Norbury said that with regard to the slide showing the proportions of silicon and total carbon in different brands of pig-iron the number of the fracture had also to be taken into account.

Mr. Roxburgh: Would not the amount of phosphorus be important too?

Dr. Norbury agreed. With regard to sulphur and phosphorus, while there might not have been any variation in the case that Mr. Upton had mentioned, in other cases manganese sulphide floated up.

Mr. Upton: The manganese in the case I mentioned was about 0.3 per cent.

Dr. Norbury said that in a higher manganese iron there would be a tendency for manganese sulphide to float up to the top. The phosphorus could also segregate, for instance it had been shown to do so in centrifugal castings.

Vote of Thanks

Proposing a vote of thanks to Dr. Norbury, Mr. S. Leetch said he greatly appreciated the work that the doctor and his colleagues were doing on behalf of foundrymen. Industry was now getting a quantity of information from people like Dr. Norbury, who were devoting their time to the various difficulties that were met with and were bringing forward definite solutions.

Mr. G. L. Oxley seconded the vote of thanks which was carried enthusiastically.

Tin Corrosion Research

As so many of the applications of tin are dependent upon the well-known ability of the metal to resist corrosive influences, it is not surprising that the International Tin Research and Development Council should regard the study of corrosion of tin and tin coatings as one of its main sections of research. In the Council's Technical Publication, Series A, No. 34, D. J. Macnaughtan and E. S. Hedges discuss the lines on which this research work is proceeding and some of the results so far obtained.

Oxygen, an important and often dominating factor in tin corrosion, is given particular study. Experiments on the atmospheric corrosion of tin have given useful information as to the type of oxide film formed. Reference is made to the theory that corrosion resistance of tin is associated with its high hydrogen overpotential, so that oxidising conditions tend to diminish corrosion resistance. Aqueous alkaline solutions, it was shown in the Council's laboratories, become corrosive towards tin if air is passed through them. It is well known that if only part of the metal has access to oxygen it becomes cathodic to the parts which are not aerated, and in consequence these latter corrode preferentially. Depolarisation and the nature of the corrosion product are other factors discussed, and the authors state that while the data so far obtained are insufficient to confirm any detailed mechanism of corrosion, they show that in certain cases corrosion is related to accessibility of oxygen.

Tin coatings on steel are considered separately. The Council's researches on the reversal of potential of the tin-iron couple, which has been proved to occur in many circumstances, have thrown new light on this problem. The influence of the composition and structure of the basis steel is the subject of other promising researches, and a great deal of work is proceeding on defects in the tin coating, their avoidance and remedying, and another field has been the perfecting of methods of determining porosity.

Copies of the above publication may be obtained free of charge from the International Tin Research and Development Council, Manfield House, 378, Strand, London, W.C.2.

Catalogue Received

Moulding Sand-Testing Apparatus. Ridsdale & Company, Limited, of 3, Wilson Street, Middlesbrough, have prepared a new leaflet (No. 150) which brings the position right up to date, including the Dawson-Hanks moisture tester—the latest addition to this subject. We know of no source other than this leaflet which crystallises the subject of sand testing from the commercial point of view as does this four-page leaflet. Practically all apparatus available is listed and priced, whilst the short technical descriptions are splendid.

Leaves from a Foundryman's Notebook

XI.—CORES AND CORE BOXES

By "RECORDER"

After deciding on the method of moulding to be adopted for any particular casting, and having constructed the pattern accordingly, it remains for the pattern-maker to produce the requisite core boxes. The decision with reference to the method of coremaking is as important as the larger consideration of moulding procedure, and although a pattern may be jointed for efficient moulding and coring, unless the core boxes are also suitably planned the casting may be costly to produce.

Each individual job should be considered on its merits, and tradition should not always be slavishly followed. For instance, in a range of any particular type of casting, although the smaller sizes are identical in design to the larger ones, it would not always be wise to make the larger by the method which served efficiently for the smaller.

Fig. 1 illustrates the top casing of a vertical engine, the interior of which is well ribbed to stiffen it around the doorways, etc. The best method of moulding this example is by making the whole of the mould in the bottom box, with a plain top, that is, casting it upside down to the illustration.

The author has seen patterns such as this jointed along line AB for moulding half in the bottom and half in the top box, these patterns being supplied from a jobbing pattern shop together with a half core box. This method is not ideal from the foundry point of view, as in ramming a deep top box as would be necessary for this, considerable "lifting," etc., is required. Also a joint down the centre of a casting of this type leaves an unsightly mark which detracts from the appearance of the finished engine. The vertical method of moulding is therefore superior and is the method adopted. The consideration of core-making determines the type of core box supplied.

The large radius C on the pattern, Fig. 1, necessitates radius D on the core to ensure metal thickness. Shall this be cut out of the bottom of the core box or produced by other means? This depends on whether the core is turned over or not. In the smaller sizes the core can be rammed in the core box and the whole turned over, before stripping the box, the core being then dried, it has to be turned over again before insertion in the mould.

This latter turning over, if not done carefully, often results in a cracked core, and when the core gets on the big side, this turning over will often be found impracticable. Then, for smaller castings of the type of Fig. 1, the core can be made in a box with a bottom which has the required fillet D cut in, but for larger sizes the core must be built the way it goes in the mould, or, in other words, the core box must not be turned over, but the side and ends of the core box withdrawn, and the core left standing.

To ensure an even thickness along the edges, loose pieces of fillet as A, Fig. 2, should be laid along the bottom of the box, Fig. 3. This box is made as a frame and is held together by bolts, on the larger sizes. Bolts also are used in the centre of the box to keep it from springing, and so maintain it parallel; otherwise the core would be on the big side. Like the example in a previous article, this core box must have an allowance to counteract the tendency of the core to "grow," and thus ensure correct metal thickness.

Loose Fillet Used

To make the core, this box, which has no bottom, is placed on a level sand bed on a cast-iron plate, and the fillets laid down. The core is then made on a cast-iron grid. In the larger sizes one grid is not considered sufficient to keep the core from warping, when lifted, so two are used. The example just described may be considered rather simple; yet probably a large job of this nature might occasion as much difficulty as a more complicated core of smaller size.

As the tendency of modern design is toward smaller, high speed machines, a brief note with reference to their cores and core boxes may not be out of place. Often a job may be required with a complicated exterior—as for example, a cylinder with a number of fins around its body and various valve pockets, etc.—when it will be found that making the outside in cores is a superior method of manufacture. In fact moulding by any other method may be considered impossible because of the impracticability of stripping the pattern.

In moulding from a pattern, limitations are imposed, it can only be stripped one way and

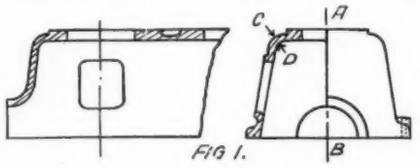


FIG 1.

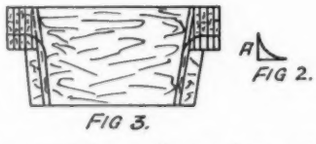


FIG 2.

FIG 3.

all loose pieces must be small enough to enter the cavity formed by the pattern, while a core can be stripped from its six sides and any intermediate direction, also no limitations are imposed as regards blacking, etc.

In core box construction for this type of job, however, one should ensure an adequate opening on the top of the box to enable the core to be rammed. Any pieces on top carrying bosses, etc., should be made in sections, to allow of their easy ramming, which makes a better job than bedding down one large piece all over the top of the box.

(*Concluded from next column.*)

metal should remain at a sufficiently high temperature in the thinnest and remotest parts of the die. Air vents for a rapid removal of the air must also be included.

Apart from the faults encountered in ordinary castings, die castings often develop porosity in certain parts of the casting. These porosities consist of agglomerations of small air cavities. They may be caused by the separation of gases dissolved in the molten metal, or by vaporisation of grease or oil which may have found its way into the die or, finally, by air bubbles formed in the molten metal due to its turbulent motion in filling the die. These defects may be readily overcome by avoiding as much as possible any contact between the furnace gases and the molten metal as well as by a suitable design of the die and air vents.

THE Hauts Fourneaux de Longwy et de la Sauvage have declared a dividend of 150 fcs. per share for 1935 in addition to the 200 fcs. per share already paid in October last.

Present-Day Position of Die Casting

Mr. P. Bastien, in a Paper which he presented to the VIIth Congrès International des Mines, de la Métallurgie et de la Géologie appliquée, gave a comprehensive review of this subject at its present day stage of development. The abstract printed below has been made by "Light Metals Review," the house organ of the British Aluminium Company.

Tin base and lead base alloys were the first to be used for die casting purposes. They have excellent casting properties, low melting points, and do not attack the steel dies. Their use is, however, restricted owing to their low mechanical properties. Zinc-base alloys are at present being widely used for die casting. Two types of alloys have been developed which are particularly suitable for this purpose. Their compositions are:—

1. Cu = 3 per cent.; Al = 4 per cent.; Mg = 0.04 per cent.; remainder Zn.
2. Al = 4 per cent.; Mg > 0.3 per cent.; remainder Zn.

Additions of aluminium increase the tensile strength and casting properties of zinc. It has also been recognised that metal of considerable purity must be used if satisfactory mechanical as well as corrosion-resisting properties are to be obtained.

In the case of aluminium alloys used for die casting the aluminium-silicon and aluminium-silicon-copper-nickel alloys are replacing the use of aluminium-copper alloys. The addition of silicon has the effect of improving the casting properties of aluminium as well as decreasing the shrinkage on cooling.

The average mechanical values obtained with these alloys are a tensile strength of 22 kg. per sq. mm. and elongation of 1.5 to 2 per cent. and a Brinell hardness of 60.

Magnesium-aluminium-zinc alloys are also being used for die casting. With the latter and to a lesser extent also with the aluminium alloys, precautions have to be taken to avoid oxidation of the molten metal. The molten aluminium alloys also have a tendency to become contaminated with iron by dissolving the iron off the walls of the containing vessels, *e.g.*, melting crucibles. This fact also necessitates the use of special alloy steel for the dies.

In recent years there has been a tendency to apply the pressure die casting methods originally developed in connection with copper alloys to the casting of light metal alloys.

The use of high pressures (200 to 250 kg. per sq. cm.) enables a much lower casting temperature being used at which the casting metal is in a pasty condition. At the lower temperature used the quantity of iron dissolved by the aluminium is very much less, resulting in a longer life of the dies. In certain cases pressure die casting has been found to result in an increase in mechanical properties.

Die casting machines can be divided into two classes: those in which the compression chamber is immersed in the molten metal and the second type in which the die casting machine is a separate unit, the molten metal being transferred from the crucible by means of a ladle. In the former class the compression is generally obtained through the use of compressed air. In the second type compression is usually by means of a piston and very high pressures are used.

A correct design of the die is of great importance if satisfactory results are to be obtained. It should be borne in mind that in die casting the metal enters the die with a very high speed. The design of the die should be such as to allow the metal to fill the mould as regularly as possible with the minimum of turbulence. The

(*Concluded in previous column.*)

Acid-Proof Enamelling on Cast Iron*

By P. C. STONE

The author has, as is well known, been producing in large quantities, acid-proof enamel finishes on cast iron since the beginning of 1931, and on sheet iron and steel, particularly cooker linings and interiors, since 1923. His experience is based on the production of over 4,000 tons during four years of acid-proof enamelled cast iron, and really large quantities of acid-proof enamel on sheet iron and steel. Thus the author can claim to know from actual experience some of the difficulties that are attached to this work, and how to overcome them.

Acid-proof finish on sheet metal is easily secured for many reasons, the most obvious one being that the stock, or metal, is now produced free from impurities. This can be said truthfully, no matter whether the metal be ingot iron or prepared steel. The same condition of purity cannot be claimed for cast iron, particularly so far as the surface of the metal is concerned.

Surface Cleanliness Important

Just as one obtains enamel defects caused by slag, scale, and other faults in sheet metal, which will cause wasters in any class of sheet-metal enamelling, so one cannot expect to obtain perfect results on cast iron, when surfaces resistant to acid, etc., are the goal sought, if there be burnt-in sand or foreign matter in the form of slag, etc., in the surface of the casting. Blasting often only closes in this dirt instead of removing it, and trouble is then bound to occur in the shape of fine boiling and blisters.

Cast iron and its manufacture involve many variables. Its composition, the method employed in moulding, and sand used for making the mould, and in many cases (although fortunately this does not occur in the best foundries) cupola practice, are often mere guess-work. Often the author has noticed that the moulders are very careless in not cleaning the moulds before closing the boxes, prior to casting the metal. Dirt that is left in the mould spoils the face of the casting, is often burnt-in, and is the cause of much trouble.

Again, metal that is not clean, or not hot enough to run freely through the mould, will not cast soundly. Yet in pouring it must not be too hot, or it burns in the sand unless it is very refractory. But, of all the foundry faults prevalent, experience has shown that incorrect gating causes most trouble, often being too near to the main casting, and hence the slag, etc., that should be in the gate is often several inches in the casting.

It has been noticed that the best results have been obtained when a trap has been made in the gate to collect the slag, etc., and the sand in use for making the mould, particularly for the face of the casting, is of a highly refractory nature, specially milled for the job in hand, and which does not easily burn in.

Wherever lugs for taking screws occur, these should be cored out if at all possible. One firm has done this for years, prior to the enamelling era, and their castings enamel without any of the trouble that is usually experienced where solid lugs occur. Thus if the enameller obtains a sound casting which is free from all external defects after blasting, a foundation is laid for success in acid-proof enamelling on cast iron.

The actual analysis of cast iron has been found to be of importance, and should be kept within the limits specified as suitable for enamelling, but this will vary on each plant, as there does not seem to be either a method of making, or a metal, which gives the same result in every plant. A personal test for metal suitable for this work is that if it can be ground and polished, free from pin-holes and dark patches, such as years ago would be demanded for "Berlin Black" and bright steel finish, it can be successfully enamelled, provided always that it is fairly even in thickness, and free from heavy lugs, unless cored, and made with a refractory facing sand.

Daily Tests Advocated

It is essential that a daily check on each day's cast be made by some responsible person, and the castings enamelled as a test, and the results recorded for comparison. It is astonishing how often it will be found by doing this that the moulding shop has "slipped up," and that by accident many castings made on a particular day are not suitable for enamelling. By using a daily test, one can avoid putting into stock castings that the test has proved to be unsuitable for enamelling in a really high-grade finish.

For the best results with acid-proof enamelling, daily co-operation in its fullest sense, between the moulding shop and the enamel department, is one of the greatest factors towards success. Many trials should be made, and continued daily, until the best method of making the mould, running the metal, and the correct sand to use are found to suit a particular plant. This daily test should continue, as much valuable information will be obtained from the results and records of the tests. Design is of paramount importance, and lugs and heavy sections are to be avoided, unless cored.

New Demands

The demand for better-quality enamels has been increasing by leaps and bounds during the past few years, and the reason for personal researches into acid-proof enamels has been that it has been felt for years, if enamellers are to preserve their industry from the invasion of stainless metal, they must produce enamel surfaces which are acid proof, so that, when the article is produced, it can safely be offered to the customer as not only something of beauty and usefulness, but one that will resist the action of acids and alkalis in domestic use, which may accidentally be spilled upon its surface. If enamel finishes are acid proof, they will have all the advantages of porcelain surface, with the resistance of stainless metal. This should be a great selling factor, and encourage enamellers to pursue their efforts to produce this finish on all enamelled surfaces.

Practical Factors

A point to be borne in mind is that often the article is warm when fruit-juices, etc., are accidentally spilled upon the surface, and in this condition the attack is more severe. It is also necessary that the enamel surfaces withstand thermal and mechanical shock; therefore, the enamel must be applied direct on to the casting.

Matt coats, which are semi-fused, make it possible to cover almost any casting, but if this be studied, it will be seen that for cooking and domestic apparatus, and many articles that are enamelled externally, the enamelled surface cannot remain intact if the temperature change is frequent. The enamel very often easily chips, and it has been found to cause much trouble to supply authorities. Unfortunately, it is unreliable where temperature changes are rapid and frequent, as in cooking apparatus. This fact is sad, but true. In this connection, it must be said that the use of matt ground coat is often forced on the enameller by the quality of the castings sent to him.

Often there is obvious dirt on the casting which cannot be blasted out, accompanied by huge blow-holes, and extremely heavy sections in comparison with the rest of the job, also a very delicate colour may be demanded by the customer. This often makes matt ground coat a necessary evil.

Basic Desiderata

Thus, there are these facts:—That the castings must be clean, even in thickness, free from burnt-in sand, and heavy lugs (unless cored), thoroughly annealed, and properly blasted. The enamel must be applied direct, in order to offer a finish that is not only pleasing in appearance, but resistant to acid, alkali, thermal, and mechanical shock. The process of enamelling in acid proof enamel requires every care in application, but it is quite easy when the shop has settled down to its peculiarities, and some operatives have a preference for working with acid-proof enamels over all others.

Results can definitely be obtained that show a large percentage of good work, but the daily analysis of the output is strongly urged, whilst complete details of all defects must be compiled, so that the causes of the defects be allocated, as to whether the scrap is caused by design, iron, blasting, enamel, or carelessness. The results should be recorded so that causes of defects can be controlled, and by process of elimination, the cause of the trouble reported and removed. In allocating these defects, it is essential that they be honestly and properly done by an inspection independent of the enamel department and the foundry.

Acid-Proof and Acid-Resisting

In view of the remarks in a previous Paper* it is essential here to make a distinction between acid-resisting and acid-proof enamels. A personal view is that no shadow or stain should show with a test of 10 per cent. solution of either citric, hydrochloric, or sulphuric acids—hence the term *acid proof*. *Acid-resisting* enamels will often show a shadow or stain, and in a strong light it is quite noticeable. Therefore, as there is so little difference in working the two finishes, let enamellers demand that their enamels come under the heading of acid proof.

It makes a slight difference to the fusing point of the enamel, and for most successful results higher temperatures are necessary. In order to demonstrate that even very high temperatures do not mean disaster, it seems desirable to state

* A Paper read before The Institute of Vitreous Enamellers, Mr. W. Todd presiding.

* FOUNDRY TRADE JOURNAL, October 3, 1935, p. 253.

that the author has produced in the early days acid-proof enamels firing as high as 820 deg. C. successfully, without distortion, in grey sponge mottle. In this connection it should be added that these enamels were not only acid and alkali proof, but also highly resistant to thermal and mechanical shock. The major fault was boiling which occurred at the heavy lugs, and dirty gates, but this defect has since occurred with lower fusing non-acid-proof enamels, applied direct to the same castings.

On finish, however, these enamels firing at 820 deg. C. bear no comparison with the modern acid-proof enamels. Therefore, the castings must not only be clean to look at, but also, as far as practicable, of even thickness and clean throughout. In modern practice it has been found that 760 to 780 deg. C. *maximum* produces an enamel surface which is brilliant and smooth in appearance, free from distortion, and stands all the tests previously stated.

Annealing and Sand-Blasting

Annealing is quite an important part of the operation, and must be thoroughly done. A temperature of 80 deg. C. for 30 min. has proved best in personal experience, and all heats and times have been tried, often with varying results, but the above temperature, using full loads, has proved best. As soon as cold, the casting should be sand- or shot-blasted, and whether mechanically or hand blasted, this operation must be thoroughly carried out. The most effective pressure has proved, in personal experience, to be 80 lbs. air pressure, free from oil and water, and using No. 16 grit. Flint grit may produce the best results, but for reasons of the health of the workers, which one must at all times consider, steel grit is now largely used, but where possible the use of 10 per cent. of flint with the steel grit, not only cleans the grit, but helps to avoid smudge, and is a very good indicator of the path of the blasting operation.

Handling Rusty Castings

Rusty castings, or castings that have been out in the weather, definitely cause trouble in enamelling, particularly where the finish is acid-proof. As soon as the castings are blasted they should be subjected to inspection, care being taken to blow all the dust, metallic or otherwise, off the castings, and if really clean enough for acid-proof enamelling, passed to the filler. The importance of blowing-off the dust is obvious, and much money can be saved by doing it, because if not done the dust, metallic or otherwise, is carried forward to the spraying booths, where it is either covered in when enamelling the casting, in which case it shows through as black specks, or blown off the castings by the spray gun, into the scrapings. If metallic in nature, this dust can be removed by magnetic separation, but if of a flint or graphitic nature it will cause much trouble when the enamel is again reconditioned for use.

Perhaps the most important thing to remember in acid-proof enamelling, direct, or any high-grade finish, is that the shorter the time from the annealing process to the finish of the article, the greater is the chance of success, but certainly 24 hrs. is the limit of time.

Fundamental Differences

Acid-proof enamels differ greatly from ordinary enamels in composition. In modern acid-proof frits the alkali is present in very large quantities, and therefore the liquor in the milled enamel requires considerable assistance to hold up in suspension the particles of frit. The effect of this peculiarity causes many curious surfaces in application, such as the enamel running off the plate or casting; rings or lines similar to crazing, and often called "shore lines" because of the gradual ebbing marks of the water as it dries out.

There are many chemicals for setting-up in common use, such as soda aluminate, potash alum, ammonia, acetic acid, hydrochloric, sulphuric acid, zirconium oxychloride, barium chloride, and many others. Each acid-proof frit will have the set-up that is best, and when found should be adhered to. In practice it has been found that the water content is a most important thing to bear in mind in grinding acid-proof enamels. They are very sensitive to water; one pint extra in 100-lb. mill charge may mean a considerable difference in the stability of the liquid enamel. This, of course, is controlled by the particle size to which the frit is ground. Therefore, consideration, in loading a mill that has been washed out, must be given to the moisture that is left on the pebbles, and in all cases, once the quantity of water is established for a particular acid-proof enamel, it must not be allowed to vary unless the mill has been washed out.

Handling Acid-Proof Enamels

The test for a suitable set-up for acid-proof enamel is that it shall remain in suspension even for weeks after grinding, without having to be adjusted daily. The enamels should be diluted to spraying strength immediately before use, by some responsible person under the supervision of the enamel control superintendent. Acid-proof enamels are sprayed with a full flowing coat, which, however, is a false thickness, owing to the set-up that is used, but this is necessary in the case of cast iron enamelling. If a thin coat be applied, there is a tendency when fusing for the iron to burn through the enamel.

Acid-proof enamels for use on sheet iron are prepared in the same way as for cast iron, but as they are sprayed on to a ground coat, can be applied thinner. The same care at the mill is definitely required. The troubles due to spraying enamels, generally, are well known, and vary in character according to the enamel and the casting, but in acid-proof it is usually because too thin a coat of heavily set-up enamel has been applied. The firing operation is always important in any enamel, and the same care is required for best results with acid-proof.

Firing Acid-Proof Enamels

In firing acid-proof enamels, it is necessary that they have the proper time for maturing in the furnace. It is useless speeding up the time at a higher temperature, it is better to increase the weight of the load at the correct temperature. In these days of time studies, there would seem no reason why rapid firing should not be a success, but actually there is a very definite reason. Any one attempting to speed up the correct maturing time has quite a lot of trouble in prospect at the inspection. On the other hand, other troubles occur if the work is dragged through the furnace at a lower temperature than the correct one, in an endeavour to surface-fuse, and so keep down boiling. The result of an enamel fired in the latter way will be a weak resistance to mechanical shock.

Observant supervision, in collaboration with technical advice from the frit supplier, will establish the best time to produce best results, and this must be adhered to. The fuser should have a minimum time set for fusing, established by the superintendent. The fusing clock is adjusted for the time required, and when the bell rings the load should be examined for correct surface, and if, in the fuser's experience, it looks ready to draw, should be taken out. The time clock should serve as an indicator of the minimum time, but the actual time in the furnace varies with the weight of the load, and according to the come-back of the heat in the muffle.

Re-Coats

In cases of re-coats of enamelling, these should be proceeded with at once, and each Saturday should see the shop clear of all work in operation. It is best to start fresh each Monday, and let each week be an effort in itself, so that considerations of details peculiar to that week can be compared with others. By doing this, fresh peaks of production and standards of quality can be obtained. Also, by clearing the shop of all work, many excuses as to the causes of scrap are removed.

Much time has been spent by frit manufacturers in perfecting acid-proof enamels, so that ultimately enamellers can say of their finishes that they stand for beauty and durability in every sense. One advantage of using acid-proof enamel is that antimony as an opacifier can safely be used without quibble, as it cannot be dissolved by ordinary acids, as in the cases recently brought to personal notice, so that a powerful but cheap opacifier can be used, with satisfaction to all, but it has been found, particularly where cast iron is concerned, that zirconium, by reason of its totally inert properties, gives the best results of all, especially when applying enamels direct to cast iron.

Design and Weight

The importance of giving consideration to design, and to the weight of castings for any enamel finish, particularly acid-proof, reminds the author of an expression used by an eminent American enameller two years ago, when in this country in connection with acid-proof enamelling.

After inspecting the production on cast iron, he summed up the situation with this remark:—"Gosh, you build them like battle-ships, typical of the English." He was amazed at the weight of metal used in this country, and said that it was at least double the weight of American castings. He also said that in the United States they expect to scrap their cookers in a comparatively short period, and it was for this reason that he attributed the march of the steel cooker in that country.

The author demonstrated to him the resistance of acid-proof enamels to acid, and thermal and mechanical shock. He was astonished, and said that although America leads the way in finish, the British were in advance on durability and resistance to acid, as far as cast iron was concerned, and he, in his experience, had never seen anything like it.

Points Recapitulated

As stressed in a previous Paper,* carelessness in operation in any one of the various stages of enamelling is a great contributory cause of scrap, and special care should be taken in every stage of the process. As one starts with annealing, one should be certain that the full annealing temperature is attained, and that the casting is soaked right through. In the blasting department, whether sand, shot, or a mixture of both be used, care must be taken in cleaning the edges, and parts near the gates and heavy lugs, to cut out the burnt-in sand, etc.

Be careful to avoid graphitic smudge on the castings, caused by using grit that is over-loaded with dirt, and which should be removed automatically as the grit passes through the machine. If not removed, it is advisable to sift the grit in the shot-blasting machine once a week, and whilst not a pleasant operation, it is often the means of reducing scrap.

After the castings have been examined for correct blasting, the dust should be blown off, and the castings passed to the filling, or stopping bench. This operation should be properly done, and the paste used very stiff, and rammed into the hole, endeavouring to leave no air pocket, and, when dry, the surplus should be thoroughly cleaned off before spraying.

Probably the greatest contributory cause under the heading of carelessness, in enamelling cast iron, is the failure to complete the cycle of operation from the annealing to the finished goods, within 24 hrs.

In the case of sheet-metal acid-proof enamelling, the time cycle is not so important, but in all classes of enamelling, the faster the progress

* *Loc. cit.*

of the work through the shop, the lower the scrap factor. The frits for making enamels today are made under definite and better supervision than ever before. All the chemicals are bought to definite specifications, which should be confirmed by the chemist in the laboratory before being stored for use. Modern enamels differ in many ways from those of even 10 years ago. They are not accidents, but are the result of many experiments on a scientific basis.

Much laboratory work has to be done before enamels are tested on a mass-production scale, and sent on to the market for use. In every case enamels should be made from the frit advised by the manufacturer as satisfactory for the job, to meet the specification of resistance demanded. The manufacturers should know what is required, and their advice should be controlled by that greatest of all teachers, practical experience in the actual production of the articles it is proposed to enamel.

Practical service by the supplier of the frit is an essential feature, because when scrap is excessive good practical service helps to reduce it to normal proportions more quickly. Although all the enamel trades are in a way similar, each section of the industry has a great study behind its success. Each branch has its special requirements, and that is why the most successful firms specialise in one or more sections, and do the job properly. It is owing to the variety of branches of the industry that modern frit suppliers, who should have a full knowledge of each, spend their lives trying to keep pace with the demands made upon them. Therefore, if frits are purchased from a firm who know from practical experience what is required, an enameller should expect to get good results, provided that stock, or metal, be satisfactory.

Materials Available

As regards finishes in acid-proof, there is no doubt that one of the strongest and most practical enamels is the acid-proof sponge mottle. It is also the most fool-proof, and can be worked easily on properly-made present day castings, if consideration has been given to the making. It is also reasonably cheap to produce, and whilst having two fires the mottle coat covers up many defects that show in the first coat, and, in any case, in the final coat they are not so evident as with plain colours.

It can be produced in pleasant light shades of colour, if required.

In conclusion, it is emphasised that acid-proof enamel is necessary to the industry, to preserve it against stainless metal. That much has to be done in design in sheet-metal parts, and more especially in castings. That foundry practice should be studied and strictly applied, not to produce a casting at a price, but a casting that will make it possible for the enameller to do his job with satisfaction to himself and the customer, so that he can produce enamel finishes without using tricks to obtain the result.

Daily co-operation between the enameller and the foundry will be an enormous contribution towards success. In any study of the subject it must never be forgotten that dirt or impurities cannot be successfully enamelled, if a good finish be required, on either sheet steel or cast iron. In the author's opinion, acid-proof enamelling will have far-reaching results, and will affect the enamel industry for years to come. It will be found that if the matter is studied without prejudice, from every angle, ultimately designs will be modern in simplicity, plain in the absence of moulds and heavy lugs, and that they will be easily cleaned both before and after enamelling, making it possible for manufacturers to offer not only a useful piece of apparatus, which is pleasing to the eye, but also resistant to acids, alkalies, and thermal and mechanical shock. Finally, as leadless enamels superseded those containing lead, so ultimately must acid-proof enamels replace all others.

The Institute of Vitreous Enamellers

ANNUAL GENERAL MEETING IN BIRMINGHAM

The second annual general meeting of The Institute of Vitreous Enamellers was held on April 29 at the Chamber of Commerce, Birmingham, under the chairmanship of Dr. J. W. Mellor, F.R.S.

The Annual Report

The second annual report, presented by Mr. W. H. Whittle, commented on the good fortune of the Institute in having retained the services of Dr. Mellor as President and on the fact that the original Council members were re-elected at the last general meeting *en bloc*. The membership of the Institute had grown during the past year and now numbered 184, comprising 83 subscribing firm members, 53 ordinary members, 26 associate members, and 22 associates. This was an increase of 50 members during the past year. The second annual conference was held last September in London, and was as successful in every way as the first conference held in Birmingham. The attendance numbered 156 at the banquet at the Victoria Hotel, Northumberland Avenue. There was a large attendance at the visit to the works of Belling & Company and also at the meeting at Olympia, where the organisers of the Shipping and Engineering Exhibition entertained the members to tea. This year the third annual conference would be held in Manchester during October.

A Scottish conference was held last Whitsuntide in Glasgow for the inauguration of the Scottish Section. A civic reception was held at the City Chambers, members being received by the Lord Provost. An organised visit was made to the works of Shanks & Company, and a technical meeting was also held, in addition to the social arrangements of a motor-coach ride through the Lowlands and an informal supper at the Central Hotel. The Scottish Section was now quite strong. There had been a series of meetings during the past season, and the membership in Scotland now totalled 17. A second Scottish conference was being held at Whitsuntide this year, details of which would be circulated at an early date.

During the last season, 27 technical meetings were held in the four sections, *i.e.*, Southern, Midland, Northern and Scottish.

Works Visits

Five works visits were organised during the past season, by courtesy of W. & T. Copeland & Sons, Limited; the Carborundum Company, Limited; the Norton Grinding Wheel Company, Limited; the Midland Electric Manufacturing Company, Limited; and Armco, Limited, all of which were well attended.

The first annual proceedings of the Institute had been published and distributed to members. The Literary Committee were now preparing the second annual proceedings, which would be published in due course. During the last year, the Institute had undertaken the distribution of works on enamelling, among which were included "Enamels," by Dr. Andrews; "Ready Remedier," by Karl Turk; and "Advanced Technique of Porcelain Enamelling," by J. E. Hansen.

The British Standards Institution had asked for nominations of the Institute for representation on the Technical Committee SF/4, on Furnaces, Ovens and Kilns, and the Council had elected Mr. Grainger and Mr. Kent to represent the Institute on this Committee. The Institute was also lending its support to an application by one of its members to the Tariffs Advisory Committee in an endeavour to secure an increased tariff on sanitary articles porcelain enamelled.

At the International Foundry Congress, held in Brussels last October, some visits were made to enamelling plants in Belgium by those members of The Institute of Vitreous Enamellers attending the Congress. This year the International Foundry Congress was to be held in Düsseldorf, and arrangements were being made for organised visits to be made to enamelling plant in Germany during this period.

The President (Dr. Mellor) said the report showed that the Institute had had an exceedingly successful year. In his opinion it was satisfactory that fault had been found with the Articles of Association. The first draft of the Articles was, of course, experimental, and he thought it would not speak well for the alertness and activity of the Council if at the present time they were content with the original draft. The existence of discontent might be taken as a guarantee that things were moving ahead. The inauguration of the Scottish Section was a gratifying development. Dr. Mellor also commented on the literary activities, remarking that one way of advancing the Institute was through the publication of the Proceedings in the fullest possible form.

The report was adopted.

The Hon. Treasurer (Mr. W. S. Grainger), dealing with the accounts, described the financial position as encouraging. There was a surplus from the previous year of £45, he said, to which had been added a surplus on the past year of £112, making a total of £157. Creditors on March 31 totalled £21, and the accounts had since been met. The assets now amounted to £178.

Dr. Mellor Re-Elected President

Dr. Mellor was re-appointed to the presidency on the proposition of Mr. S. Hallsworth, seconded by Mr. Grainger.

Acknowledging the compliment, Dr. Mellor said he greatly appreciated the honour conferred on him.

Election of other Officers

Before the meeting proceeded to the election of the remaining officers, Mr. Whittle explained that the Council were not satisfied with the phrasing of the rule relating to this matter. A Sub-Committee had had the subject under consideration and it has been further debated prior to the present meeting. Even now there was not complete agreement on the precise wording. The idea was that a given number of the Council, say one-third, should retire each year. This would ensure continuity while allowing for a proportion of new members. As matters were at the moment, however, the whole of the officers and the Council retired and offered themselves for re-appointment.

Mr. A. England said that when, a year ago, he moved the election of the officers *en bloc*, he did so on the understanding that before the next annual meeting the Article relating to the appointment of officers would have been revised.

Mr. J. T. Gray thought that until the Article had been amended there was no alternative but to repeat what was done last year and re-elect the officers and Council *en bloc*. He accordingly proposed a resolution in that sense. This was seconded by Mr. Dooley and carried.

Mr. W. Todd, as convener of the Rules Revision Committee, assured Mr. England that a great deal had been done. A point had now been reached when he could say that they were approaching a solution. Members of the Council, almost in their entirety, were agreed that means must be provided for the direct representation of the branches on the Council and it was now merely a question of phraseology. They were alive to the defects of the existing Memorandum.

The Chairman said there was a suggestion that the Scottish Section ought to be represented. Accordingly Mr. Logan was asked to serve and assented.

Miss Elliott was warmly thanked for her services as secretary, and the auditors, Messrs. Wenham Bros. & Company, were reappointed.

Enamel Mill-Room Practice

WITH SPECIAL REFERENCE TO GRINDING MILLS*

By G. STEELE

Introduction

Amongst the various sections of a vitreous enamelling plant, none needs more careful control than the milling operation. The ease with which the enamel may be applied and handled, and the quality of the finished enamel product is, to a large extent, dependent on the development and maintenance of a satisfactory mill-room technique. It will be apparent from the discussion of the different topics which comprise this Paper that this requires very close control. In fact, the subject matter of this Paper is concerned more particularly with the conditions of charging and running of ball mills which give the most satisfactory grinding.

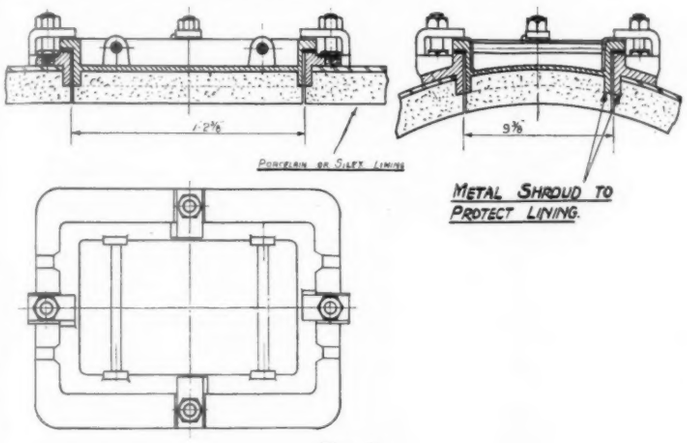


FIG. 1.

The Mill-Room and Its Equipment

It is not intended to say more under this heading than to mention that the mill room should be conveniently located in the works for the receipt of raw materials and for the distribution of the milled enamel. The room should have good lighting, adequate heating and ventilation, a fair proportion of unoccupied floor space, and ample drainage for wash water. Concrete foundations for the mills are generally recommended. Under these conditions cleanliness is readily maintained, and accurate adherence to a specified routine easily carried out, with the production of enamel of uniform quality.

There should be a sufficiency of mills to suit the range of enamels manufactured. It is false economy to operate with too few mills. The cost of additional equipment may soon be recovered in the saving in time, labour, and material resulting from less washing and cleaning of the mills. The danger of contaminating one enamel with another is also minimised.

Mill Linings

The materials used for lining ball mills are (1) porcelain; (2) silex silica rock, and (3) rubber.

(1) Porcelain brick linings are in general use for grinding white enamels. They may be made either by the dust-pressed or by the plastic process. Those made by the former process are very regular in shape, and therefore allow close joints to be made with them. They are somewhat more friable than those made by the plastic process, but the latter are not so true to shape, since they tend to warp during drying. The joints obtained with the plastic process bricks are thus somewhat wider. Porcelain bricks, if under-fired, not only wear down faster and contaminate the enamel, but wear down unevenly. The lining may even be worn through to the steel in certain spots while the adjoining brick may still be in fair condition. The penetrability of the porcelain to liquids must also be extremely low, otherwise it would not be possible to mill successive mixes of different colours satisfactorily.

(2) Silex blocks of the ordinary type give linings which are suitable only for under-coatings or second-quality enamels. Their shape is so irregular that wide joints occur which require filling with cement. Contamination of the enamel with jointing cement thus occurs. Silex blocks can be obtained with the faces ground true to shape. These are very expensive, but last about four times as long as porcelain blocks. They provide a lining quite suitable for the highest quality enamels.

(3) Rubber-lined mills are in the experimental and development stage, but their application appears to be limited to wet grinding. The lining may be as little as $\frac{1}{4}$ in. in thickness. It must be vulcanised to the metal by a special process, and this requires the transport of the cylinder to the rubber manufacturer's plant.

In fixing the lining, whether of porcelain or silex, the design of the mill should be such that there are no continuous circumferential joints between the blocks in the centre of the mill. Wear usually commences at this point, and a continuous ring of joints would be a source of weakness. To obviate this, lining is generally carried out through openings in the ends of the barrel. It is also recommended not to complete the lining of a mill in one operation, but to pause when a segment of the cylinder walls and a part of the end walls have been installed, so that the joints may dry and set, and any natural shrinkage in the cement take place before continuing. Joints should not exceed $\frac{1}{32}$ in. in thickness.

The lining requires special reinforcement in the region of the manhole and discharge openings. For this reason metal shrouds are fitted which project inwards to about half the depth of the lining blocks, which should fit accurately to the surface of the shrouds. Well fitting manhole and discharge covers are obviously an essential. This is shown in Fig. 1.

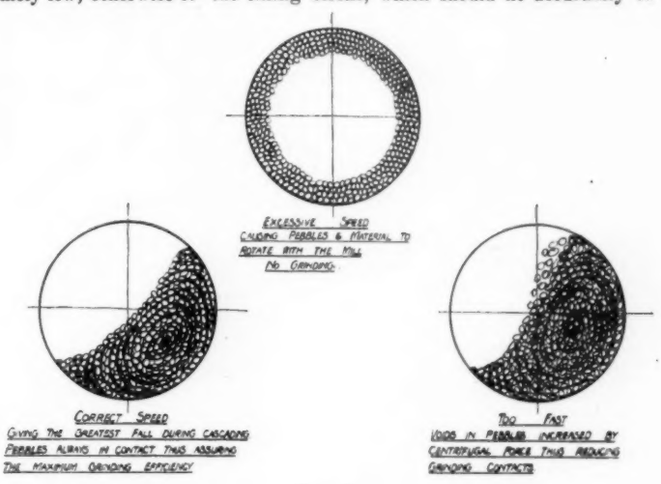

EXCESSIVE SPEED CAUSING PEBBLES & MATERIAL TO ROTATE WITH THE MILL NO GRINDING.
CORRECT SPEED GIVING THE GREATEST FALL DURING CASCADING PEBBLES ALWAYS IN CONTACT THUS ASSURING THE MAXIMUM GRINDING EFFICIENCY
TOO FAST LOSS IN PEBBLES INCREASED BY CENTRIFUGAL FORCE THUS REDUCING GRINDING CONTACTS

FIG. 2.

Grinding Media

In the vitreous-enamelling industry the grinding media are usually (*a*) flint pebbles or (*b*) porcelain balls. The flint pebbles are usually obtained either from Denmark or France. Those from Denmark are generally favoured on account of their more regular shape and freedom from cavities. In such cavities unground material tends to accumulate. On the other hand, experience in some enamel plants has shown that the Danish flints have a greater tendency to chip on the surface. In some circumstances, therefore, selected French flints free from cavities are preferred.

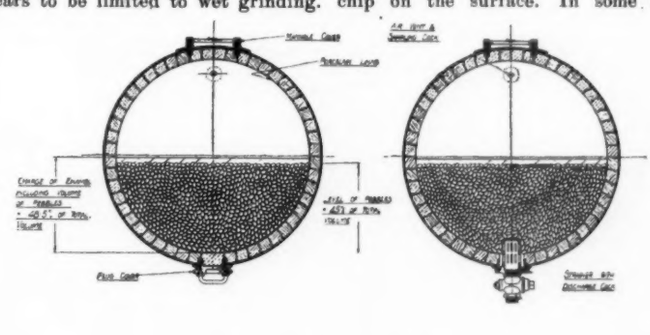


FIG. 3.

Porcelain balls, like porcelain linings, should possess negligible penetrability to liquids and considerable toughness and hardness. High-class products are available which show no absorption of fuchsin dye even under exceptionally high pressures. Such products can be used for grinding high-quality enamel. Of course,

* A Paper read before The Institute of Vitreous Enamellers in Manchester.

they should be of assorted sizes to prevent grooving of the lining due to the balls of one size always travelling in the same path.

Efficiency of Grinding—Wet Process

The efficiency of the grinding process depends on a number of factors, among which may be included (1) the size of balls or pebbles; (2) the speed of rotation of the mill; and (3) relative volume of mill, grinding media, and mill charge:

(1) The grinding action in the ball mill is a combination of percussive and rubbing actions, though in wet grinding rubbing largely exceeds impact. In either case the extent of grinding is dependent on the number of contacts taking place between the pebbles or balls themselves and between them and the lining of the mill. From this point of view the smaller the size of the grinding media the more grinding will be accomplished. The limiting effective size of pebbles or balls will thus depend on the size of the grains of frit and also on the consistency of the enamel being ground. Stiffer and heavier enamels will thus require the smallest size balls in the batch to be heavier or larger than will the thinner and more fluid preparations. It is also apparent why excessive wear would occur if mills were run for any length of time with pebbles and water only.

In practice these principles may be adapted by charging the mill with 75 to 90 per cent. the normal volume of balls of the smallest effective size, using much larger ones for the remaining 10 to 25 per cent. These larger units act as agitators. S. W. Kendall has recommended the sizes quoted in Table I for grinding average types of paint, and they are suitable also for enamels.

(2) The speed of rotation of ball mills has an appreciable effect on the efficiency of the grinding process, and the time required to mill a batch of enamel. When a mill is directly coupled to an electric motor with variable speed adjustment, it is possible to test by including an ammeter in the circuit at what speed the maximum amperage is recorded. This is the speed at which the motor is performing the greatest amount of work on the mill. As shown in Fig. 2 at greater speeds the balls tend to rotate with the mill, being held by centrifugal force, and perform less useful work on the material to be ground.

Several rules have been proposed. For wet grinding specifically, there is Mellor's expression $\text{R.P.M.} = 43.3 \sqrt{\frac{1}{D-d}}$, where D is the internal diameter of the mill and d the average diameter of pebbles in feet.

S. W. Kendall has evolved the expression $\text{R.P.M.} = \frac{140 \times M \times A \times C \times F}{\sqrt{D}}$ from experiments on grinding paints and lacquers. Factor M depends on the lining and grinding media. For porcelain balls and lining its value is 1. For flint pebbles and silex lining it is 1.04. For the smooth linings used in enamel work, factor A is also equal to 1. C is a consistency factor which is 1 for normal consistency, and may reach 1.5 for thin bodied products and 0.6 for highly viscous mixes. F is a factor depending on the inside diameter of the mill. For mills of inside diameter 24–48 in. F is given the value 1.07; for under 24 in., F is given the value 1.21. D is the inside diameter in inches.

Table II gives the results of evaluating these expressions for various size mills.

It will be seen that both Mellor's and Kendall's formulæ agree for normal consistencies, and they are also substantiated by practical experience to a considerable degree.

(3) When a mill is rotated at the appropriate speed there occurs cascading of those balls which have been raised to the maximum height, over the surface of the other balls to the lowest position. Maximum grinding occurs when this cascading surface is also a maximum. This is attained with an apparent volume of grinding media of 45 per cent. of the volume of the mill. The voids in this apparent volume will not be far short of 40 per cent. Indeed a number of tests on porcelain balls and on pebbles of sizes and proportions suitable for grinding media failed to reveal more than slight variations from this value of 40 per cent. For the most efficient grinding, therefore, there should be enough material to fill this void space. Less than this amount means that the full grinding surface of the pebbles is not being utilised continuously, whilst an amount in excess of this entails a proportion of frit not in contact with a grinding surface.

On this basis the correct volume of dry frit to be added should be 40 per cent. of 45 per cent. of the volume of the mill, *i.e.*, 18 per cent. On theoretical grounds there may be some justification for adding rather more than the 18 per cent.

(1) The charge is required just to cover the pebbles and not merely to come up to the average level of the surface of pebbles.

(2) A proportion of frit will be trapped between pebbles, thus they will be spaced slightly further apart than when unmixed with other materials.

Slightly more frit will, therefore, be needed to occupy the interstices between the pebbles. For these reasons it is suggested that the volume of frit to be charged should be raised to 21.5 per cent. of the volume of the mill. The results of a number of tests have also confirmed that the most efficacious volume of charge is quite close to this value.

Water Additions

As regards the quantity of water to be added in the charge, the ideal, from the point of view of the extent of grinding surface, would be that the water should merely occupy the voids in the frit. Measurements of the voids in different samples of commercial frits have shown that these also are in the vicinity of 40 per cent. Thus the water to be added should be 40 per cent. of the apparent volume of frit, or 8.5 per cent. of the volume of the mill—an amount which again agrees well with practice.

To summarise, therefore, the best conditions for wet-grinding efficiency would appear to be (1) a charge of grinding media of as small a size as practicable, with a few larger ones to act as agitators and crushers of the larger pieces of frit; (2) the charge to be 45 per cent. of the volume of the mill; (3) the speed of rotation to be such that the charge remains compact but rises to the maximum height on rotation, maintaining the pebbles in this compact form; (4) the frit to constitute 21.5 per cent. of the volume of the mill; and (5) the water to constitute 8.5 per cent. of the volume of the mill. These points are represented pictorially in Figs. 2 and 3. Suggested weights of frit and water for different sized mills are given in Table III and converted to weight measurements.

While the above conditions are put forward as likely to yield enamel slip most efficiently, regard must be paid to the *convenience* of working. It

TABLE I.—*Return of Ball Sizes in Effective Grinding (Kendall).*

Dia. of mill. Ft.	Grinding media.	Per cent. and size of Small balls.	Per cent. and size of Large balls.
1 to 2	Porcelain	90 per cent. —¾ in.	10 per cent. —2 in.
	Pebbles	85 „ —1 to 1½ in.	15 „ —2½ in.
2 to 3½	Porcelain	85 „ —¾ in.	15 „ —2 in.
	Pebbles	80 „ —1 to 1½ in.	20 „ —2½ to 3 in.
3½ to 5½	Porcelain	80 „ —¾ in.	20 „ —2½ in.
	Pebbles	75 „ —1 to 1½ in.	25 „ —3½ to 4 in.

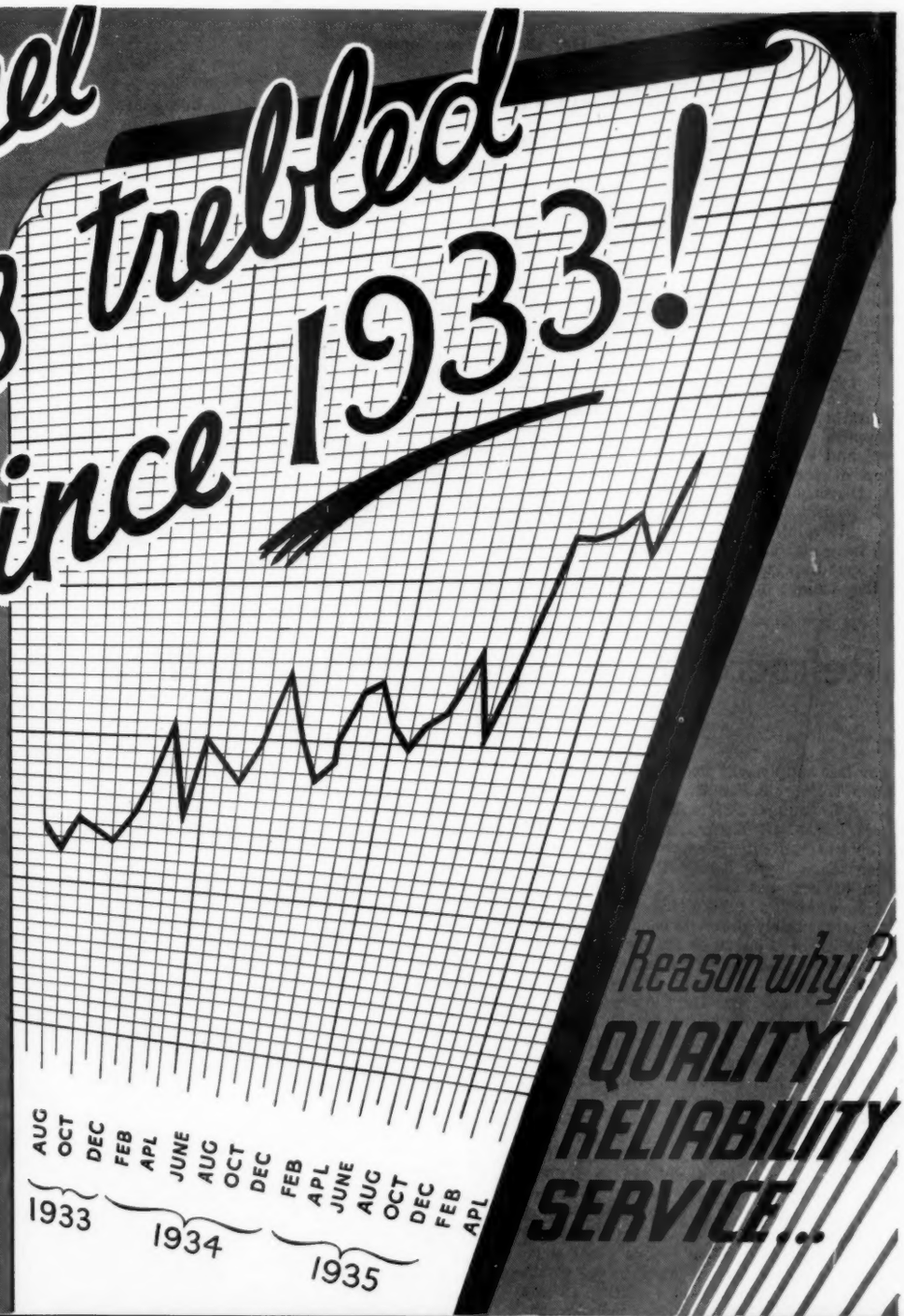
TABLE III.—*Suggested Charges for Various Sizes of Mills—Porcelain Lined.*

Size of mill, outside dimensions. Dia.	Length.	Total capacity, cub. ft.	Pebbles, lbs.	Charges (lbs.). Frit. 80 lbs. per cub. ft.	85 lbs. per cub. ft.	90 lbs. per cub. ft.	95 lbs. per cub. ft.	100 lbs. per cub. ft.	Water, lbs.
Ft. in.	Ft. in.								
2 0	2 0	3.44	155	59	63	66	70	74	18½
2 6	2 6	7.55	340	130	138	146	154	162	41
2 9	2 9	10.50	472	181	192	203	214	226	57
3 0	3 0	14.10	635	243	258	274	288	304	76
3 6	3 6	20.00	900	344	366	387	408	430	108
4 0	4 0	31.8	1,430	547	582	616	650	685	171

TABLE II.—*Effective Mill Speeds.*

Dia. of mill.	Inside dia. of mill.	Speed of mill in revs. per min. Kendall's formula. High viscous.	Normal.	Thin.	Mellor's formula.
Ft. ins.	Ft.				
7 0	6.52	10.2	17.0	25.4	17.3
6 0	5.55	11.0	18.5	27.7	18.6
5 6	5.05	11.6	19.3	28.9	19.5
5 0	4.55	12.2	20.3	30.4	20.7
4 6	4.06	12.9	21.6	32.3	22.4
4 0	3.54	13.8	23.0	34.5	23.6
3 6	3.06	14.9	24.8	37.2	25.4
3 0	2.67	15.9	26.6	39.8	27.4
2 9	2.38	16.9	28.3	42.2	29.1
2 6	2.13	17.9	29.8	44.6	30.6
2 0	1.64	23.0	38.0	57.2	35.4
1 9	1.40	24.9	41.0	62.0	38.0
1 3	1.00	29.5	49.2	74.0	45.2
1 0	0.75	34.0	55.5	85.0	53.0

Enamel Sales trebled since 1933!



• • GRAPH SHOWS AMAZING GROWTH OF SALES OF BLYTHE ENAMELS

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OPORTO (Portugal)
TEPLITZ SCHONAU
(Czecho Slovakia)

may be more economical to grind larger charges than those recommended, despite the fact that more than a proportionate increase in time would be required. The saving in unloading cost might more than compensate for the loss in grinding efficiency.

To maintain grinding efficiency, it is obviously necessary to maintain the quantity of the balls or pebbles at the correct value. Different methods may be employed. Each month the mill may be emptied, the broken and undersized pebbles removed, and enough new pebbles added to restore the correct quantity. Another method is, after an experimental test to find the loss, to add a small quantity daily to maintain the required proportion. With this method also periodic inspection is required. Obviously the pebbles added must be scrupulously clean.

It is a *sine qua non* of good milling practice that strict adherence to the standard programme is maintained once that has become established. This applies to the weighing of the charge, the renewal and sizing of the pebbles, the speed of rotation of the mill and the duration of the grind. Directly coupled mills have an advantage in this respect in that belt slippage is eliminated. Revolution counters or other timing devices have also been found of service in maintaining grinding routine and uniformity. However, they cannot dispense with the necessity of sampling and testing the fineness of the enamel before running it off.

Dry Grinding

The best conditions for wet grinding are, as has just been shown, those which allow of the maximum use of the grinding surface of the pebbles by a process of rubbing. The best conditions for dry grinding are not so obvious. It may be conceded that where the material to be ground is initially of a fair size (1 or 2 in. in diameter, for example) and is tough rather than brittle, then the maximum percussive action is required. This is attained by rotating the mill at such speeds that the balls are projected from the periphery and fall the maximum vertical distance on to the material and crush it by impact. Various workers have investigated this problem mathematically and obtained formulæ for the speeds of rotation which agree with practice. Such speeds are considerably in excess of wet grinding speeds. In fact, the loss of energy from splashing would make such speeds out of the question for wet grinding.

It is suggested, however, that in grinding a material such as enamel frit by the dry process, a material which is brittle and relatively easy to reduce in size, more success would be achieved by running at wet grinding speeds. For at the higher speeds such as are normally used in dry grinding to obtain maximum impact, the charge and pebbles are open and loose, and very little rubbing action can occur. At wet grinding speeds the charge and pebbles are coherent and compact, and maximum rubbing occurs. The conditions for best dry grinding of enamel would, therefore, appear to be very closely akin to those for wet grinding, more particularly as regards the size of the balls or pebbles, the amount of grinding media, and the volume of the dry charge. The speed of rotation may even be rather less than for wet grinding, owing to the reduced slippage on the walls of the dry charge as compared with the wet one.

Conclusion

The subject considered in this Paper has been essentially the running of ball mills so as to achieve most efficient grinding. The suggestions made with reference to the quantity and sizing of the grinding media, the quantity of the charge, and the speed of rotation, are put forward as a reliable, though necessarily somewhat approximate, basis for best operation. They accord to a large extent with the best standard practice, but more experimental work is required before more precise statements can be made.

The author desires to express his appreciation of the assistance given by Mr. W. Marshall, of the Ferro Enamelling Company, in the preparation of this Paper.

Refractories for Enamelling Muffle Furnaces

In our last supplement we printed a Paper by Mr. John Walker, A.R.S.M., B.Sc., on the subject of "Refractories for Enamelling Muffle Furnaces." MR. H. WHITAKER, who was in the chair, opened the discussion, and said that he had been much impressed by the lecturer's description of how the composition and physical properties of refractories could be varied in order to meet widely different conditions of service. The average buyer of an enamelling furnace was quoted a certain figure for some parts to be constructed in ordinary firebrick, and a considerably higher figure for the same parts in "special" brick, but his knowledge of the actual differences in the two qualities was rather scanty. Mr. Walker had gone into his subject very deeply, and had thrown light on what had been a mystery to many present.

MR. W. H. WHITTLE said that, concentrating on the development of the furnace as they had seen it during the last few years, he would like to ask Mr. Walker if he would tell them if it had been found advantageous to cool by water pipes the area immediately behind the portion of the furnace whereon the slag forms. He would be glad if Mr. Walker would give them some indication as to whether ordinary bricks would be adequate, if they were water cooled, or was it necessary to go to the cost of the more expensive construction by the installation of carborundum bricks? Could Mr. Walker tell them if there had been any very detrimental indications due to oil firing, or what was his experience as to the life of an enamel furnace, under those conditions?

Water-Cooled Refractories

MR. WALKER, speaking with regard to the water-cooling of refractories, said that this did make a small improvement with ordinary fireclay refractories. He thought that to get the most benefit from water or air cooling, silicon carbide must be used. Referring to the question of oil-fired combustion chambers, this had definitely made the conditions more severe for the refractory maker. In fact, it might be said that the use of oil firing had led to the development of better bricks for that part of the furnace.

Refractories for Oil-Fired Furnaces

MR. H. BRADLEY asked what was the best brick for an oil-fired furnace, in the firing chamber, not in the muffle. Having tried three or four different types of refractory material, he had found none of them which stood up as well as he thought some of the brick manufacturers would have been able to have made them. The life of the arch, as they might call it, of the firing chamber, had not been lasting much over 15 to 18 months. He would like Mr. Walker's opinion as to what he considered was a really good refractory for the firing chamber of an oil-fired furnace.

Rate of Heat Transfer

MR. WALKER illustrated his reply with a lantern slide, and said that with regard to the combustion chamber, fairly rapid heat transfer through the arch was not detrimental and, possibly, under some conditions, rather desirable. It was desirable, however, to maintain a low rate of heat transfer through the side walls, as heat transfer in that direction usually meant heat lost. For the arch he strongly recommended the use of fused alumina, as it had no tendency to oxidise. It was volume-stable at a very high temperature; it had a good thermal conductivity, and heat transfer was rapid. As far as the sides of the walls were concerned, one might say that conditions, even in oil-fired combustion chambers, varied considerably. Where the temperatures were on the low side, it was found that a brick containing 52/54 per cent. alumina was adequate, and had not too high a thermal conductivity. It was not, of course, a heat insulator.

On the other hand, where very high temperatures were encountered, it was necessary to use fused alumina in that zone, to obtain the volume stability and strength under load, which were necessary to prevent shrinkage and squatting. The thermal conductivity in this case was unnecessarily high, and one had to meet this by insulating the outside. With high temperatures where oil firing was used, he recommended a fused alumina brick as the best type of refractory available at present. He did not know how exacting the conditions mentioned by Mr. Bradley were, but under some of the conditions which he, the lecturer, had seen, in oil-fired combustion chambers, he would feel pleased if a life of 18 months was secured.

Silicon Carbide for Gas Producers

MR. A. CONNOLLY said that Mr. Walker had differentiated between a firing chamber and a gas producer with silicon carbide for the firing chamber, because it would not clinker up. Did it make a difference in the gas-producing chamber? He said that with silicon carbide the firing box would not clinker up. That was one of the advantages; slag would not stick to it. He thought Mr. Walker mentioned another kind of brick for the gas-producing chamber.

MR. WALKER said that in the case of severe clinkering, with adhesion of clinkers to the bottom few courses in the gas producer, one might safely use silicon carbide in those parts. The same applied to furnaces of the semi-producer type in which the producers were more or less built into the furnace. Conditions were much the same, and silicon carbide could, generally, be used with advantage at similar points. If they were able to use it in such a way that a certain amount of air cooling was also available at the back, that was a definite advantage. With the air cooling there was a tendency also to chill the slag on the inner face, but, apart from that, silicon carbide was in itself non-clinkering.

MR. CONNOLLY: How does silicon carbide withstand clinker pokering?

MR. WALKER replied that he did not know how brawny the stokers were. It was the strongest and hardest commercial refractory there was, and because the clinker did not adhere, vigorous poking and slicing was unnecessary.

Life of Silicon-Carbide Refractories

MR. W. B. CLEVERLY said that Mr. Walker at the beginning of the Paper had spoken of silicon-carbide bricks expanding and perishing at low temperatures. Later, the lecturer had specified a range of 800 and 1,000 deg. C. He, the speaker, presumed that was range Mr. Walker meant in the first part of the Paper. He then gave a life of six months to two years as a possible life to be obtained from silicon-carbide muffles. He, the speaker, would suggest that a silicon-carbide brick which only gave a life of six months was a very poor sample. On the other hand, with a life of two years, silicon carbide as a general rule, adequately paid for itself in increased output and fuel economy. Another

(*Concluded on page* 374.)

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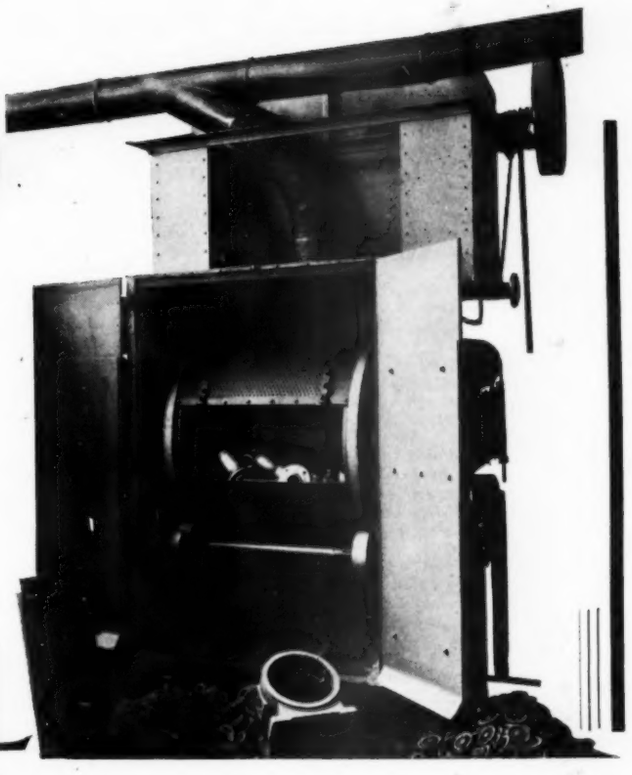

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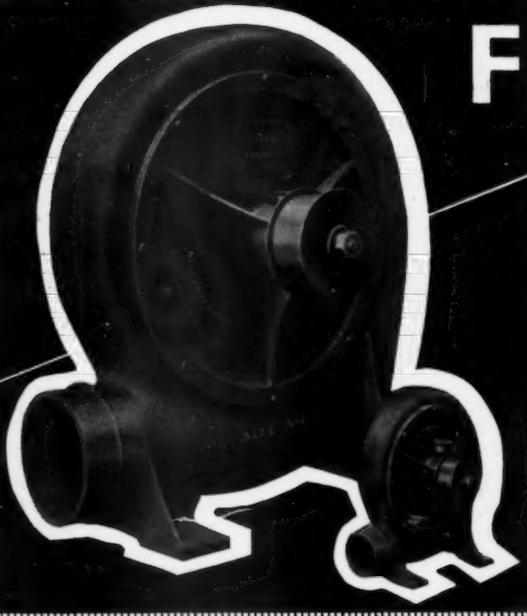

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This Week's News in Brief

Trade Talk

SWAN, HUNTER & WIGHAM RICHARDSON, LIMITED, Wallsend, have received an order from T. & J. Harrison, Limited, of Liverpool, for a 6,400-ton cargo steamer.

THE EX-GERMAN WARSHIP "Konig Albert," which was salvaged from Scapa Flow, where she had lain for 16 years, is being broken up by Metal Industries, Limited, at Rosyth.

VICKERS-ARMSTRONGS, LIMITED, Walker-on-Tyne, are to transfer the building of two "Tribal"-class destroyers of 1,850 tons from their Barrow yard to the Walker Naval yard.

G. & J. WEIR, LIMITED, of Cathcart, Glasgow, will celebrate their fiftieth anniversary on June 6. Workers over 21 years of age will receive a present of 10s., and those under 21 will receive 5s. Workers will also receive a day's holiday with pay.

THE BOARD OF DIRECTORS of Glenfield & Kennedy, Limited, Kilmarnock, have decided to maintain the annual ordinary disbursement of 10 per cent., less tax, and in addition to distribute one bonus ordinary share for every four ordinary shares now held.

JAMES LAING & COMPANY, LIMITED, Sunderland, are to reopen their shipyard as a result of the receipt of a 9,000-ton cargo ship order for the Bespian Steamship Company, of London. The engines will be supplied by George Clark, Limited, Sunderland.

ONLY FOUR VESSELS, of 7,770 tons, were launched on the Clyde during April, but the orders booked are estimated to be worth £2,500,000. There is at present about 400,000 tons under construction, which is equal to about 45 per cent. of the total in British yards.

NEARLY A HUNDRED MEMBERS of the Derby Engineering Society visited the engineering works of International Combustion, Limited, Derby, recently. They were received and escorted through the various departments by Mr. Gudgeon, works manager, and his assistants.

R. A. LISTER & COMPANY, LIMITED, of Dursley, have received an order from the organisers of the Empire Exhibition in Johannesburg, South Africa, for 30 passenger auto-trucks. They are to be used for carrying visitors inside the Exhibition grounds, which are approximately 100 acres in extent. The Exhibition opens on September 15 and will last for four months.

THE CLYDE ALLOY STEEL COMPANY, LIMITED, Motherwell, has just erected another electric arc furnace of 5 tons capacity. The furnace was previously at the Mossend works of William Beardmore & Company, Limited, which is being dismantled. The company have in view further foundry extensions, including the installation of a 1-ton induction furnace.

THE PROCEEDS from the performances by Ley's Operatic and Dramatic Society of "The Desert Song," which amounted to £62, will go towards a special fund for the endowment of an "Ian. F. Panton" bed at the Derbyshire Royal Infirmary. It is named after the late Mr. Ian. F. Panton, a director and general manager of Ley's Malleable Castings Company, Limited, Derby.

A LARGE PARTY OF INDUSTRIALISTS attended the works of William Dixon, Limited, Glasgow, on April 27, when the new coke-oven plant was opened by Lord Provost Stewart, of Glasgow, who pressed a lever to release a charge of coke from the oven into the quenching tower. The plant consists of 50 ovens, and, when in full operation, will produce sufficient coke to supply two blast furnaces.

ON THE PETITION of Mr. Ernest Musgrove Slatter, of Abbey House, Westminster, Mr. Justice Bennett, in the Companies Court last week, made an order for the compulsory winding-up of the Patent Axle-Box & Foundry Company (1934), Limited, of Wolverhampton. Mr. Buckmaster said that the petitioner was a creditor for £200, payable under an agreement between him and the company. The company did not appear and there was no opposition.

Refractories for Enamelling Muffle Furnaces

(*Continued from page 372.*)

point Mr. Walker did not stress with regard to fused alumina and silicon carbide, which possibly was of interest, was the fact that owing to their high mechanical strength, which he had just mentioned to Mr. Connolly, combustion chambers, facings and portions of the furnace which had to transmit heat could be made appreciably thinner than in fireclay, which was again enhancing their good conductivity.

MR. WALKER said that with regard to his remark concerning silicon carbide lasting from six months to two years, he was trying to indicate that conditions, even in enamelling muffles, varied to an appalling degree. He could not state why. He had seen that same silicon carbide used in two different furnaces, and had given that order of comparative life.

MR. CLEVERLY said that every application required considering on its own merits.

MR. WALKER: Absolutely.

MR. CLEVERLY referred again to low temperatures, and said that with cast-iron enamelling the temperatures were 700 and 750, and a life of five years and upwards could be expected of silicon carbide.

MR. WALKER agreed.

A Six-Year Life

MR. BRADLEY gave his evidence of the life of silicon carbide and said that the firm with which he was associated had this type of muffle, which was now in its sixth year. With the exception of it being pointed in the muffle itself, nothing else had been necessary, and it was still doing good service. He had had a new muffle in stock but it had not yet been necessary to replace it. He was speaking purely of cast-iron enamelling, no sheet-iron work at all. The range of temperature in the muffle, as shown by the pyrometer, was somewhere in the region of 760 to 780 deg. C.

Vote of Thanks

MR. WHITTLE proposed that a very hearty vote of thanks be accorded to the lecturer for his interesting and informative Paper.

The vote of thanks was carried, and MR. WALKER briefly responded.

The proceedings then concluded.

Contracts Open

Birmingham, May 14.—600 tons of cast-iron pipes and specials 54 in. to 30 in. in dia., and 830 tons of cast-iron pipes and specials 27 in. to 3 in. in dia., for the Birmingham Tame and Rea District Drainage Board. Mr. H. C. Whitehead, engineer, Rookery Park, Erdington, Birmingham.

Nottingham, May 18.—Cast-iron pipes, for the Water Department. Mr. F. W. Davies, engineer and general manager, Water Department, Castle Boulevard, Nottingham.

Oldham, May 12.—425 10-in. iron pipes, 12 ft. long, class C, B.S.S., for the Town Council. Mr. E. Parry, commercial manager, Gas and Water Offices, Greaves Street, Oldham.

Porthcawl, May 11.—1,900 yds. of 6-in., 1,200 yds. of 5-in., 1,560 yds. of 4-in., and 400 yds. of 3-in. cast-iron water mains, for the Urban District Council. Mr. A. C. Rees, engineer and surveyor, Council Offices, Porthcawl. (Fee £3 3s., returnable.)

Wellington, June 9,—Large air-compressor driven by electric motor or heavy oil engine, piston displacement 600 or 800 cub. ft. per min., for the New Zealand Government Public Works Department. The Department of Overseas Trade. (Reference T.Y. 30,091.)

New Company

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Ross & Company (Foundry), Limited.—Capital, £5,000. Directors: N. Ross, Forge House, Killamarsh, Sheffield; A. H. Whiteley.

Personal

DR. THOMAS SWINDEN has changed his home address to 12, Broad Elms Lane, Sheffield, 11.

MR. CECIL LISTER has been elected to the board of R. A. Lister & Company, Limited, engineers, of Dursley.

SIR WILLIAM BRAGG, Director of the Royal Institution, has been presented with the Faraday Medal, awarded annually by the Institution of Electrical Engineers.

MR. J. F. BENBOW, an official of the Staveley Coal & Iron Company, Limited, has left Chesterfield, to take up a position at Taunton with the same company.

MR. GEORGE LONGDEN, late assistant foundry manager of the Sheepbridge Coal & Iron Company, Limited, and late assistant foundry manager of Craven Bros., has been appointed travelling representative for Thomas Wilkinson & Company, Limited, of Middlesbrough.

MR. ROBSON WHITFIELD WILLEY, an employee in the foundry of Rainwater Castings, Limited, Margaret Street, Ashton-under-Lyne, received the certificate on vellum of the Royal Humane Society last week. On January 31 Mr. Willey dived twice into a canal to rescue a drowning man.

THE STAFF of the Clyde Steel Alloy Company, Limited, Motherwell, recently made presentations to Mr. James Colville, commercial manager, and Mr. James McArthur, works manager, on their appointment to the board of directors. Mr. William McLachlan, secretary of the company, presided, and paid high tribute to his two colleagues.

MR. G. N. SHAWCROSS, M.B.E., a mechanical engineer, of the L.M.S. Railway Company, in charge of the Horwich (Lancs) Locomotive Works, retired on May 1, after 46 years' service with the company. Mr. Shawcross was Vice-President of the Institution of Locomotive Engineers from 1925 to 1931, and is a member of the Institute of Mechanical Engineers.

Wills

EMMETT, W., late manager of Woolfold Engineering Company, of Bury ...	£1,244
RUSHTON, J. L., director of Textile Machinery Makers, Limited, and formerly chairman of Dobson & Barlow, Limited	£329,517

Obituary

MR. ROBERT HALL, a member of the firm of Robert Hall & Sons (Bury), Limited, textile engineers and ironfounders, of Hope Foundry, Bury, died last week at the age of 85 years. He was a son of Robert Hall, the founder of the firm, and for many years had been associated with the concern, first as a partner and later as a director. He retired about 17 years ago. He was appointed a Justice of the Peace in 1906, resigning 18 years later on account of his age.

MR. WALTER JOSEPH FLAVELL, founder of the firm of W. J. Flavell & Company, patternmakers, of West Bromwich, died on April 30, aged 73 years. Mr. Flavell was a Past-President of the Birmingham Branch of the Institute of British Foundrymen, and a member of the committee of the West Bromwich and District Manufacturers' Association. He was appointed a Justice of the Peace in 1930, and was associated with many social and philanthropic organisations in the district.

Forthcoming Events

MAY 7-8.

Iron and Steel Institute:—Annual Meeting in London, at the Institution of Civil Engineers, Great George Street, S.W.1, at 10 a.m.

MAY 26.

Institution of Civil Engineers:—Ordinary Meeting: "Recent Developments in Metallurgy and their Influence on Engineering," Paper by M. Eugene Shneider, at 6 p.m.

MAY 27.

Manchester Association of Engineers:—Visit to the works of Mather & Platt, Limited, Park Works, Newton Heath, at 2.30 p.m.

Institute of British Foundrymen

JUNE 9-12.

Annual Conference in Scotland.

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Raw Material Markets

A meeting of heavy steel makers was held in London last Thursday, when it was decided that sales can continue to be made at to-day's prices for delivery up to June 30 next. Increased costs of production had led many to believe that prices would be raised. A meeting of Midland pig-iron producers was held on the same day and a similar decision was reached, but it is certain that for delivery after June 30 an increase of 5s. on present quotations will be made. At this meeting the price of forge pig-iron for delivery to foundries was fixed at 3s. per ton below the appropriate No. 3 foundry level. This represents an increase in prices of 1s. per ton.

Pig-Iron

MIDDLESBROUGH.—Deliveries of Cleveland foundry iron in this area have been almost completely suspended. None of the blast furnaces is engaged on this material, and stocks are almost negligible. Regular consumers have been able to obtain supplies from the Midlands, but requirements are considerably in excess of supplies. Export trading is, of course, totally neglected. It is unlikely that any home-produced iron will be available before July 1, when the increase of 5s. per ton comes into operation. For delivery before that date values are only nominal, with No. 3 Cleveland G.M.B. iron quoted at 70s. per ton in the Middlesbrough and Falkirk areas, 72s. on the North-East Coast, and 73s. on Clydeside. The steelworks continue to take up the total output of basic iron.

The demand for hematite pig-iron is such that the whole of the output is going into immediate consumption. Most users are well covered for several months, and they are reluctant to place orders for delivery after the end of July, owing to the uncertainty of prices. Makers, in some cases, have obtained a small premium on the ruling prices, which, until July 31 next, are based on No. 1 East Coast quality at 77s. per ton delivered in the Scottish, Northumberland, Durham, and North Yorkshire areas.

LANCASHIRE.—Many consumers in this area are complaining of late deliveries in spite of the fact that April despatches represented a considerably larger tonnage than those of March, and prospects for the next month or two indicate a further expansion in this respect. For delivery to users in the Lancashire price zone, offers of Derbyshire and Staffordshire brands of No. 3 iron are largely nominal on the basis of 78s. per ton, with Northants at 76s. 6d., and prices for delivery after the end of June at 5s. per ton in excess of these figures. Scottish No. 3 foundry iron is at 89s. per ton delivered in the Manchester area, while East Coast hematite is quoted at from 84s. 6d. to 85s. and West Coast material at around 85s. 6d., both delivered equal to Manchester.

MIDLANDS.—Supplies of pig-iron in this area are short and many users are having to wait before their needs can be satisfied. Prices remain unchanged, the minimum figures delivered Birmingham and Black Country stations being 72s. 6d. per ton for Northants No. 3 and 75s. for Derbyshire, Lincolnshire and North Staffordshire No. 3. There is a heavy demand for forge pig-iron, but supplies are not sufficient to execute users' orders. The price of this grade is now 3s., instead of 4s., under the appropriate No. 3 foundry level. For ironworks the quotation is still at 5s. per ton below No. 3 foundry. The general engineering and motor trades are taking up large tonnages of the better quality irons. Prices are not controlled, and vary within wide limits according to the position of supply. Medium-phosphorus iron is offered at from 80s. to 87s. 6d., low-phosphorus from 92s. 6d. to 100s., and special refined iron from £6 10s. to £7 15s., delivered Birmingham and Black Country stations. The hematite market maintains its firm tone, the demand against contracts being heavy, while complaints of belated deliveries are not infrequent. West Coast mixed numbers are quoted at £4 8s. 6d., East Coast No. 3 at £4 7s. 6d., and Welsh mixed numbers £4 7s., delivered Midland stations in 10-ton lots. An additional 1s. 6d. per ton is charged if delivered into works. These prices are only applicable until the end of July, when prices, to be announced later, will be in operation.

GLASGOW.—Several grades of pig-iron are extremely difficult to procure in this district and works in the Glasgow area have had to curtail production owing to their inability to secure supplies of Middlesbrough foundry iron. Both hematite and basic qualities are being heavily consumed. Prices of Scottish foundry iron are unchanged at 79s. for No. 3 at furnaces, with 2s. 6d. per ton extra for No. 1. The Continent has exported considerable supplies of foundry iron to this country, despite the tariff. Lack of supplies of pig-iron is restricting the output of the light-castings makers, who are very active. The official prices of Cleveland iron remain at 70s. f.o.t. Falkirk and 73s. f.o.t. Glasgow. Hematite manufacturers are unwilling to sell at the official figure of 77s., a small premium being generally stipulated.

Coke

The condition of the coke market is unusual for the time of year, which, as a rule, is comparatively quiet, with makers generally having to induce users to enter the market by allowing price concessions. Prices are still very firm and it is unlikely that they will be lowered even for delivery during the late summer months. For delivery to Birmingham and district best Durham coke varies from 41s. 6d. to 43s. for best quality, with other grades down to 38s. 6d., while Welsh coke ranges from 38s. 6d. up to 50s. per ton.

Steel

Business in the steel market is limited to a great extent by the inability of the steelmakers to accept fresh orders, says the official report of the London Iron and Steel Exchange. No increases in the prices of heavy steel will take place before the end of June, and, except in special cases, the manufacturers are confining their quotations to delivery before that date. In some instances, however, the producing works are sold well into the third quarter of the year. Similar conditions rule in the semi-finished steel industry, where some relief has been experienced by large imports of Continental steel. In this department also the works are sold out for many weeks to come, and it is difficult to place orders for some descriptions of British steel. Business in finished material has been quiet, although there has been no slackening in the pressure to obtain deliveries against contracts.

Scrap

For many months past consumers of scrap material in the Cleveland district have had to be content with only partial satisfaction of their requirements, but supplies have at last overtaken the demand and most users are now well covered. Good, heavy, melting steel remains firm at 57s. 6d., while heavy machinery cast-iron is steady at 65s. and ordinary heavy foundry metal is at 62s. 6d., although higher prices have been paid for the latter material. Active conditions continue to prevail on the Midland market, all qualities of scrap being well taken up. Heavy machinery in cupola sizes is at 70s., good heavy at 65s., and clean light at 52s. 6d. to 55s. Short, heavy, steel, suitable for foundry purposes, is still in short supply at 67s. 6d. per ton delivered works. Prices remain firm on the Scottish market, but trading has been on a rather reduced scale during the past week. Heavy steel scrap is still quoted at 57s. 6d., with heavy basic or heavy iron and steel scrap mixed at 5s. per ton less. Cast-iron machinery scrap, in pieces not exceeding 1 cwt., and suitable for cupolas, has been active at 71s. 3d. to 72s. 6d., while 67s. 6d. to 68s. 6d. has been obtained for ordinary cast iron, to the same specification. Piling wrought-iron scrap is at 70s. per ton, delivered f.o.t. consumers' works, but rather more has been obtained for special quality.

Metals

Copper.—This market has again been dull. The weekly report issued by Brandeis, Goldschmidt & Company, Limited, states that "several events have taken place in Europe and the United States which have made for unsettlement in the markets. The trend of the French elections has been regarded as unfavourable, and the financial restrictions imposed in Poland are evidence of the difficulties under which the gold bloc countries are labouring. The principal factor which has made for uncertainty was the weakness in the United States stock market, which has influenced the corresponding market in England. Considering these factors, the decline in copper has not been pronounced. The principal industrial centres in this country continue very satisfactory consumers, and the wave of unsettlement is likely to be only of a temporary nature." Buying in the United States has been quiet, and sales on April 29 were 492,000 lbs., the lowest day's volume for some time. Leading copper fabricators have advanced the price of sheet and other products by ¼ cent a lb. owing to increased operating costs. The increase has no relation to the price of the metal.

Daily market prices :—

Cash.—Thursday, £36 17s. 6d. to £36 18s. 9d. Friday, £37 2s. 6d. to £37 3s. 9d.; Monday £37 1s. 3d. to £37 2s. 6d.; Tuesday, £37 to £37 2s. 6d.; Wednesday, £37 to £37 1s. 3d.

Three Months.—Thursday, £37 3s. 9d. to £37 5s. Friday, £37 8s. 9d. to £37 10s.; Monday, £37 7s. 6d to £37 8s. 9d.; Tuesday, £37 6s. 3d. to £37 7s. 6d.; Wednesday, £37 6s. 3d. to £37 7s. 6d.

Tin.—Trade demand has been on an increased scale during the past week, and the market has had an improved tone. In the United States consumers are taking up supplies regularly, but the tonnage involved is not heavy. Deliveries during April are estimated to have amounted to between 6,000 and 6,500 tons. Mr. W. H. Gartsen (Henry Rogers, Sons & Company) in his monthly tin statistics states that the total visible supply at the end of April, 1936, was 12,415 tons, as compared with 14,747 tons at the end of March, 1936, and 16,287 tons at the end of April, 1935. The carry-over at the Straits Settlements was 2,728 tons, and at the Arnhem (Holland) smelter 813 tons.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £207 15s. to £208; Friday, £207 15s. to £208; Monday, £207 to £207 5s.; Tuesday, £205 5s. to £205 15s.; Wednesday, £205 to £205 10s.

Three Months.—Thursday, £202 to £202 10s.; Friday, £202 5s. to £202 10s.; Monday, £200 15s. to £201; Tuesday, £199 15s. to £200; Wednesday, £199 15s. to £200 5s.

Spelter.—Buying interest in this country is chiefly confined to the brass-making industry, which is taking up large tonnages of high-grade zinc. There has been a slight improvement in the condition of the galvanising trade, but, on the whole, this market remains dull. On the Continent quieter conditions have prevailed, while the only encouraging feature of the United States market is the favourable development in the galvanised sheet industry. The rate of output is now 65 per cent. of capacity, as compared with 54 per cent. a year ago.

Official quotations were as follow :—

Ordinary.—Thursday, £14 18s. 9d.; Friday, £14 15s.; Monday, £14 16s. 3d.; Tuesday, £14 17s. 6d.; Wednesday, £14 17s. 6d.

Lead.—Consumption in this country has been maintained on a satisfactory scale, but on the Continent conditions have been colourless. The tone of the market in this country is quite sound, and some improvement is anticipated in the near future.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £16 2s. 6d.; Friday, £16; Monday, £15 17s. 6d.; Tuesday, £15 18s. 9d.; Wednesday, £15 17s. 6d.

Company Reports

Park Gate Iron & Steel Company, Limited.—Dividend of 3 per cent. for the year ended March 31, 1936, after writing off £40,000 for depreciation and placing £25,000 to reserve.

Glenfield & Kennedy, Limited.—Final dividend of 6 per cent. on the ordinary shares, making 10 per cent. Directors recommend that £81,250, forming part of the reserve, be capitalised and distributed among ordinary holders in the proportion of one bonus ordinary share for every four ordinary shares held.

Anderson-Grice Company, Limited.—Gross profit for year to September 30, 1935, £3,815; brought in, £163; interest on loans and investments, etc., £230; dividend from George Anderson & Company, of Canada, Limited, £201; depreciation, £1,624; taxation, £561; interest on loans and overdraft, £157; loss on realisation of investments, £38; dividend of 3d. per ordinary share; carried forward, after preference dividends, £599. Meeting, May 12.

TOR ROCK SAND

It is now possible to obtain from a deposit in the Midlands, a moulding sand possessing all the excellent characteristics of the Scottish Rock sands. This sand we have called Tor Rock Sand. It is well bonded, coarse in grain, and highly permeable.

The advantage this sand offers to iron founders in the Midlands and the South is obvious. Railway rates, which represent a high proportion of the cost of moulding sand when delivered are reduced considerably. Please write for full particulars and samples.

CHEMICAL ANALYSIS

Silica	86·8 %
Ferric Oxide	1·43%
Alumina	7·6 %
Lime	·22%
Magnesia	·18%
Titanic Oxide	·18%
Alkalies	1·8 %
Loss on ignition	1·6 %

MECHANICAL ANALYSIS

Very Coarse Sand (+ 1 mm)	16·5%
Coarse Sand (+·5 mm—1 mm)	16·0%
Medium Sand (+·25 mm—·5 mm)	11·0%
Fine Sand (+ ·1 mm—·25 mm)	30·0%
Silt Grade (+ ·01 mm—·1 mm)	7·0%
Clay Grade (—·01 mm)	19·5%

GENERAL REFRACTORIES Ltd.,

Genefax House, Sheffield.

Telephone: Sheffield 31113 (6 lines). Telegrams: "Genefax, Sheffield"

London Office:
Russell House,
Adelphi, W.C.2.
Telephone: Temple Bar 7361.
Telegrams:
"Genefax, Rand-London."

Scottish Office:
156, St. Vincent St.,
Glasgow.
Telephone: 5250.
Telegrams:
"Genefax, Glasgow."

South Wales Office:
11, Wind St.,
Swansea.
Telephone: 3680.
Telegrams:
"Genefax, Swansea."

MANUFACTURERS OF HEAT RESISTING AND HEAT INSULATING MATERIALS OF EVERY DESCRIPTION

RAW MATERIALS—PRICE LIST

(Wednesday, May 6, 1936)

COPPER

	£ s. d.
Standard cash	37 0 0
Three months	37 6 3
Electrolytic	41 7 6
Tough	39 15 0
Best selected	40 5 0
Sheets	70 0 0
India	51 0 0
Wire bars	41 12 6
Ingot bars	41 12 6
H.C. wire rods	45 2 6
Off. av. cash, April	37 0 2½
Do., 3 mths., April	37 5 11½
Do., Sttlmnt., April	37 0 1½
Do., Electro, April	41 6 8½
Do., B.S., April	40 15 0
Do., wire bars, April	41 10 9
Solid drawn tubes	10½d.
Brazed tubes	10½d.
Wire	6¼d.

BRASS

Solid drawn tubes	9½d.
Brazed tubes	11½d.
Rods, drawn	8¾d.
Rods, extd. or rlld.	5d.
Sheets to 10 w.g.	8d.
Wire	7¾d.
Rolled metal	7½d.
Yellow metal rods	5d.
Do. 4 × 4 Squares	5¾d.
Do. 4 × 3 Sheets	5¾d.

TIN

	£ s. d.
Standard cash	205 0 0
Three months	199 15 0
English	205 5 0
Bars	206 10 0
Straits	206 0 0
Australian (nom.)	205 0 0
Eastern	204 10 0
Banca	206 0 0
Off. av. cash, April	209 9 0¾
Do., 3 mths., April	203 16 3
Do., Sttlmt., April	209 8 0

SPELTER

	£ s. d.
Ordinary	14 17 6
Remelted	13 10 0
Hard	11 15 0
Electro 99.9	17 0 0
English	15 10 0
India	12 15 0
Zinc dust	19 10 0
Zinc ashes	4 5 0
Off. aver., April	15 5 1⅞
Aver. spot, April	15 3 7½

LEAD

	£ s. d.
Soft foreign ppt.	15 17 6
Empire (nom.)	16 13 9
English	18 0 0
Off. average, April	16 3 3¾
Average spot, April	16 1 11¼

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

Zinc sheets, English	24 10 0 to 25 0 0
Do., V.M. ex-whse.	24 10 0 to 25 0 0
Rods	27 5 0

ANTIMONY

English	69 10 0 to 70 10 0
Chinese, ex-whse.	58 0 0
Crude, c.i.f.	28 10 0

QUICKSILVER

Quicksilver	11 15 0 to 12 5 0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	8 17 6
45/50%	12 15 0
75%	17 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
20/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£21 0 0 to £22 0 0
Ferro-tungsten—	
80/85%	3/- lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	33 0 0
4/6% car.	21 10 0
6/8% car.	21 0 0
8/10% car.	21 0 0
Ferro-chrome—	
Max. 2% car.	33 10 0
Max. 1% car.	36 5 0
Max. 0.70% car.	37 5 0
70% carbon-free	9½d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	6/3 to 6/9 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese (net)—	
76/80% loose	£11 5 0 to 11 15 0
76/80% packed	£12 5 0 to 12 15 0
76/80% export	(nom.) £10 5 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to $\frac{1}{16}$ in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅜ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£ s. d.	£ s. d.
South Wales—		
Heavy steel	3 5 0	to 3 6 0
Mixed iron and steel	3 0 0	to 3 1 0
Heavy cast iron	2 18 0	to 3 0 0
Good machinery	3 2 6	to 3 5 0
Cleveland—		
Heavy steel	2 17 6	
Steel turnings	2 0 0	
Heavy cast iron	3 2 6	
Heavy machinery	3 5 0	
Midlands—		
Light cast-iron scrap	2 12 6	to 2 15 0
Heavy wrought iron	3 7 6	to 3 10 0
Steel turnings	2 2 6	
Scotland—		
Heavy steel	2 17 6	
Ordinary cast iron	3 8 0	
Engineers' turnings	2 2 6	
Cast-iron borings	1 17 6	to 1 18 6
Wrot-iron piling	3 10 0	
Heavy machinery	3 11 3	to 3 12 6

London—Merchants' buying prices, delivered yard.

Copper (clean)	31 0 0
Brass	20 0 0
Lead (less usual draft)	14 10 0
Tea lead	11 0 0
Zinc	9 0 0
New aluminium cuttings	75 0 0
Braziery copper	28 0 0
Gunmetal	30 0 0
Hollow pewter	160 0 0
Shaped black pewter	120 0 0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	72/6
,, No. 3	70/-
,, at Falkirk	70/-
,, at Glasgow	73/-
,, No. 4	69/-
Forge No. 4	69/-
Hematite No. 1	77/-
Hematite M/Nos.	76/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	77/-
,, d/d Birm.	88/6
Malleable iron d/d Birm.	119/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	72/-
,, No. 3 fdry.	75/-
Northants forge	69/6
,, fdry. No. 3	72/6
,, fdry. No. 1	75/6
Derbyshire forge	72/-
,, fdry. No. 3	75/-
,, fdry. No. 1	78/-
Scotland—	
Foundry, No. 1, f.o.t.	81/6
,, No. 3, f.o.t.	79/-
Hem. M/Nos. d/d	77/-
Sheffield (d/d district)—	
Derby forge	69/6
,, fdry. No. 3	72/6
Lincs forge	69/6
,, fdry. No. 3	72/6
W.C. hematite	90/-
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	78/-
Staffs fdry. No. 3	78/-
Northants fdry. No. 3	76/6
Cleveland fdry. No. 3	78/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	89/-
Clyde, No. 3	89/-
Monkland, No. 3	89/-
Summerlee, No. 3	89/-
Eglinton, No. 3	89/-
Gartsherrie, No. 3	89/-
Shotts, No. 3	89/-

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)	10 2 6	
Nut and bolt iron	8 10 0	to 9 0 0
Hoops	11 0 0	and up.
Marked bars (Staffs) f.o.t.	12 10 0	
Gas strip	11 0 0	and up.
Bolts and nuts, ¾ in. × 4 in.	15 15 0	and up.
Steel—		
Plates, ship, etc.	8 15 0	to 8 17 6
Boiler plts.	9 5 0	to 9 7 6
Chequer plts.	10 7 6	
Angles	8 7 6	
Tees	9 7 6	
Joists	8 15 0	
Rounds and squares, 3 in. to 5½ in.	9 7 6	
Rounds under 3 in. to ⅜ in. (Untested)	9 1 0	
Flats—8 in. wide and over	8 12 6	
,, under 8 in. and over 5 in.	8 17 6	
Rails, heavy	8 5 0	to 8 10 0
Fishplates	12 10 0	
Hoops (Staffs)	9 16 0	
Black sheets, 24g. (4-t. lots)	11 10 0	
Galv. cor. shts. (,,)	13 10 0	
Galv. flat shts. (,,)	14 0 0	
Galv. fencing wire, 8g. plain	15 0 0	
Billets, soft	5 17 6	and up.
Billets, hard	6 17 6	to 7 2 6
Sheet bars	5 15 0	to 6 5 0
Tin bars	5 15 0	to 6 5 0

PHOSPHOR BRONZE

	Per lb. basis
Strip	10½d.
Sheet to 10 w.g.	11½d.
Wire	11½d.
Rods	12⅝d.
Tubes	11½d.
Castings	14d.
	12½d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	21.31
No. 2 foundry, Valley	19.50
No. 2 foundry, Birm.	15.50
Basic, Valley	19.00
Malleable, Valley	19.50
Grey forge, Valley	19.00
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	36.37½
Billets	28.00
Sheet bars	28.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.85
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.80
Steel hoops	2.10
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.10
Wire nails	2.10
Plain wire	2.40
Barbed wire, galv.	2.60
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	25/- to 32/6
,, furnace	20/- to 21/-
Durham foundry	23/6 to 24/6
,, furnace	21/-
Scotland, foundry	30/-
,, furnace	25/- to 26/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	18/9
,,	28×20 ,,	37/6
,,	20×10 ,,	27/-
,,	18⅞×14 ,,	19/6
C.W.	20×14 ,,	15/6 to 16/3
,,	28×20 ,,	34/3
,,	20×10 ,,	23/-
,,	18⅞×14 ,,	15/9 to 16/-

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£6 0 0 to £7 0 0
Bars-hammered, basis	£16 0 0 to £16 10 0
Bars and nail-rods, rolled, basis	£15 15 0 to £16 0 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£30 0 0 to £31 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars and rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£ s. d.	
April 30 ..	36 17 6	dec. 2/6
May 1 ..	37 2 6	inc. 5/–
„ 4 ..	37 1 3	dec. 1/3
„ 5 ..	37 0 0	„ 1/3
„ 6 ..	37 0 0	No change

Electrolytic Copper

	£ s. d.	
April 30 ..	41 0 0	dec. 7/6
May 1 ..	41 5 0	inc. 5/–
„ 4 ..	41 7 6	„ 2/6
„ 5 ..	41 7 6	No change
„ 6 ..	41 7 6	„ „

Standard Tin (cash)

	£ s. d.	
April 30 ..	207 15 0	No change
May 1 ..	207 15 0	„ „
„ 4 ..	207 0 0	dec. 15/–
„ 5 ..	205 5 0	„ 35/–
„ 6 ..	205 0 0	„ 5/–

Tin (English ingots)

	£ s. d.	
April 30 ..	207 15 0	dec. 5/–
May 1 ..	208 0 0	inc. 5/–
„ 4 ..	207 5 0	dec. 15/–
„ 5 ..	205 10 0	„ 35/–
„ 6 ..	205 5 0	„ 5/–

Spelter (ordinary)

	£ s. d.	
April 30 ..	14 18 9	dec. 1/3
May 1 ..	14 15 0	„ 3/9
„ 4 ..	14 16 3	inc. 1/3
„ 5 ..	14 17 6	„ 1/3
„ 6 ..	14 17 6	No change

Spelter (Electro, 99.9 per cent.)

	£ s. d.	
April 30 ..	17 0 0	dec. 1/3
May 1 ..	16 17 6	„ 2/6
„ 4 ..	16 17 6	No change
„ 5 ..	17 0 0	inc. 2/6
„ 6 ..	17 0 0	No change

Lead (soft foreign, prompt)

	£ s. d.	
April 30 ..	16 2 6	dec. 2/6
May 1 ..	16 0 0	„ 2/6
„ 4 ..	15 17 6	„ 2/6
„ 5 ..	15 18 9	inc. 1/3
„ 6 ..	15 17 6	dec. 1/3

Lead (English)

	£ s. d.	
April 30 ..	18 0 0	dec. 5/–
May 1 ..	18 0 0	No change
„ 4 ..	18 0 0	„ „
„ 5 ..	18 0 0	„ „
„ 6 ..	18 0 0	„ „

AVERAGE MONTHLY PRICES OF FURNACE COKE D/D MIDDLESBROUGH

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1904	0 13 9	0 13 9	0 13 3	0 14 3	0 14 6	0 14 3	0 14 3	0 14 3	0 14 3	0 14 0	0 14 0	0 14 6	0 14 1½
1905	0 14 9	0 15 3	0 15 3	0 15 3	0 15 6	0 15 6	0 15 6	0 15 6	0 15 6	0 15 6	0 15 9	0 17 0	0 15 5½
1906	0 17 6	0 17 6	0 17 0	0 17 0	0 17 0	0 16 6	0 17 0	0 17 0	0 18 3	0 18 6	0 19 0	1 0 0	0 17 8½
1907	1 4 6	1 5 0	1 5 0	1 0 6	1 2 0	1 1 0	1 1 0	1 1 0	1 2 0	1 1 6	1 0 0	0 17 0	1 1 8½
1908	0 16 0	0 16 0	0 15 6	0 16 0	0 16 3	0 16 0	0 15 6	0 15 6	0 15 6	0 15 3	0 16 0	0 16 0	0 15 9½
1909	0 16 0	0 15 3	0 15 0	0 14 9	0 15 6	0 15 9	0 15 6	0 15 6	0 16 6	0 17 0	0 17 6	0 17 0	0 15 11½
1910	0 18 4½	0 18 6½	0 18 0	0 18 0	0 17 10½	0 17 0	0 16 1½	0 15 9½	0 15 11	0 16 0	0 15 9½	0 15 8	0 16 11
1911	0 16 0	0 15 10½	0 15 6	0 15 3	0 14 9	0 14 6	0 14 6	0 14 6	0 14 6	0 14 11½	0 15 0½	0 16 3½	0 15 1½
1912	0 17 3	0 17 3	0 18 6	0 18 10	0 19 0	0 19 4½	0 19 10½	1 0 9½	1 2 9	1 4 1½	1 5 8½	1 8 6	1 1 0
1913	1 5 9	1 4 11	1 5 0	1 5 0	1 4 9½	1 0 4½	0 19 5½	0 18 3	0 18 0	0 18 2½	0 18 6	0 18 6	1 1 4½
1914	0 18 2	0 17 1	0 17 0	0 17 0	0 17 4	0 17 6	0 17 6	0 18 5	0 18 4	0 17 9	0 17 6	0 18 5	0 17 8
1915	0 17 10½	0 17 9	1 0 4½	1 7 7½	1 9 4½	1 10 7½	1 9 7	1 7 3	1 5 4	1 4 9	1 9 6	1 13 0	1 6 1
1916	1 10 9	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6½
1917	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 14 3	1 15 6	1 11 2½
1918	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6
1919	1 15 6	1 15 6	1 15 6	1 15 6	2 1 6	2 3 9	2 3 9	2 10 6	2 10 6	2 10 6	2 10 6	2 10 6	2 3 5
1920	2 12 3	2 14 0	2 19 0	2 19 0	3 3 8	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 2 6
1921	3 1 0½	2 19 0	2 16 0	2 7 0	2 6 6	2 6 6	2 0 6	2 0 0	1 13 11	1 12 9	1 10 4½	1 8 3	2 3 6½
1922	1 7 0½	1 8 1½	1 9 7½	1 8 4½	1 7 11½	1 7 3	1 6 9½	1 6 10½	1 7 0½	1 10 2½	1 10 0	1 9 11½	1 8 3½
1923	1 11 3	1 14 6	2 0 1½	2 2 8½	2 4 4½	2 2 10½	2 1 0½	2 1 6	2 0 9½	1 18 9	1 18 8½	1 18 3	1 19 7½
1924	1 16 6½	1 14 9	1 11 11½	1 10 0½	1 8 1½	1 7 8½	1 7 3	1 6 3	1 6 0	1 5 0	1 5 0	1 5 0	1 9 5½
1925	1 4 10½	1 4 1½	1 13 3	1 2 4½	1 2 2½	1 1 5½	1 1 3½	1 4 9	0 18 10½	0 18 4½	0 19 6½	1 1 4½	1 2 8½
1926	1 2 1½	1 0 9	0 19 2½	0 18 6½	*	*	*	*	*	*	*	1 5 0	1 1 1½‖
1927	1 5 6	1 4 9½	1 6 1½	1 3 9	1 2 6	1 0 8½	0 19 4½	0 19 0	0 18 7½	0 18 0	0 17 10½	0 17 6	1 1 1½
1928	0 17 6	0 17 10½	0 18 0½	0 17 11½	0 17 8½	0 17 6½	0 17 7½	0 17 6½	0 17 6	0 17 7½	0 17 7½	0 17 6	0 17 8
1929	0 17 7½	0 18 0	0 19 0	0 19 6½	0 18 10½	0 19 10½	1 1 3½	1 1 3½	1 3 0	1 3 6	1 3 8	1 3 1½	1 0 9½
1930	1 2 6½	1 1 3	1 0 3	0 19 1½	0 17 7	0 16 10½	0 16 6	0 16 9	0 16 9	0 17 0	0 17 0	0 17 0	0 18 2½
1931	0 17 0	0 16 7½	0 16 0	0 16 0	0 15 11	0 15 5	0 15 1	0 15 0	0 15 0	0 16 9	0 17 0	0 16 6	0 16 0½
1932 ..	0 17 0	0 16 11½	0 16 5½	0 15 9	0 15 7½	0 15 6	0 15 6	0 14 9½	0 14 6½	0 14 6	0 14 6	0 15 4	0 15 6½
1933 ..	0 16 0½	0 15 11½	0 15 6½	0 15 6	0 15 6	0 15 6	0 15 6	0 15 8½	0 16 1½	0 17 0	0 17 6	0 18 9	0 16 1½
1934	0 19 1½	1 0 6	1 0 2	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	0 19 11½
1935	1 0 0	0 19 6½	0 19 0½	0 19 0	0 19 0	0 19 0	0 19 0	0 19 0	0 18 9½	0 18 9½	0 19 3½	1 1 2½	0 19 2½
1936	1 2 0	1 2 11½	1 3 2½	1 4 0	—	—	—	—	—	—	—	—	—

* Strike period. ‖ Five months.

TN ORANGE

WINCHESTER HOUSE, OLD BROAD STREET, LONDON, E.C.2.
Telegrams:- "ALKALIZE, STOCK, LONDON" Phones:- LONDON WALL 4774 (5 LINES)

AC GARNET

FINE ORANGE

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BUTTON

WILLIAM JACKS & Co

Partners J Gray Buchanan Stewart Barry R Russell Walker

FINEST ORANGE

SHELLAC

WHITE

RUBBER QUICKSILVER MICA

PALE LEMON

THE METAL EXCHANGE
Telegrams: "JACKS, METMA, LONDON." LONDON, E.C.3. Phone: LONDON WALL 4774

FINE WHITE

Notice

Small Advertisements in this section of the Journal are accepted at the prepaid rate of 6d. per line, first line in capitals counting two, average 6 words per line. Minimum charge for one insertion 3/-

(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED

FOREMAN, non-ferrous foundry; 12 years' experience with Government contracts, gun, brass and phos. bronzes.—Box 700, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY Foreman desires re-engagement. Has had sound practical experience in high-class engineering; capable organiser. Excellent credentials.—Box 710, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY Manager or Foreman; 12 years' experience in complete control in the manufacture of rainwater and soil goods, builders' and general engineers' castings; sound cupola practice; up-to-date methods; first-class references.—Box 698, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

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